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SCIENTIFIC RESEARCH AND THE BRITISH ECONOMY

IN his recent book "Co-operative Industrial Research", Prof. R. S. Edwards attempts to assess the contribution which the research associations are making to industrial development and to the application of existing, or of new, knowledge. An article by a young American economist and man of science, Mr. R. L. Meier, who has some experience in the United States in fundamental and applied research, has since been published in "The Manchester School of Economic and Social Studies". This article attempts to assess the extent to which science is utilized in the British economy and the value of the fundamental research at present being carried out in Great Britain. Mr. Meier claims that his judgments are based on his experience both in the United Kingdom and in the United States and on intimate contacts with current developments in physics, chemistry, ferrous metallurgy, biology and electrical engineering. Internal evidence may suggest some scepticism as to this rather large claim; but, when all due allowance has been made for personal limitations, there is much in Mr. Meier's paper that is instructive and indeed suggestive, and he has a perspective that is rarely found in the voluminous literature on industrial research.

Dealing first with the economic value of research, Mr. Meier points out that for certain categories of research it is impossible to supply economic standards of value, and the time-lags which are involved and the indirect uses to which the new knowledge is put tend to confuse any economic analysis. Some research must be treated as an operating expense, some as part of the capital investment which is amortized over a period of years, and some as part of an inexhaustible resource. Even where the research is expected to yield an economic return, and where the goals of the projects are explicit and the time-lag between outlay and the prospect of income no more than five to ten years, the uncertainty in evaluating the return may be more than $\pm$ 50 per cent.

Mr. Meier suggests that the evidence indicates that it has been good business to expand and re-equip industrial research both in Great Britain and in the United States. On the basis of figures available for the United States, he suggests that from the national point of view, for every dollar put currently into research, three dollars are obtained as a result of making use of past research, and that for each dollar expended upon research in the United States economy, about ten dollars of net saving are required. Nevertheless, there are limits to the extent to which research can wisely be prosecuted, imposed by the availability of suitably trained men of high intellectual calibre, the availability of capital and the receptivity to changes in patterns of trade.

Mr. Meier warns us against attempting to remake the British economy in the North American image; but, with that warning in mind, his analysis of trends in fundamental research in Great Britain, based in part on the sampling of notes or letters appearing in

one week's issue of *Nature*, is the most interesting part of his paper. Some of his conclusions are in sharp contrast with Sir Hubert Henderson's view that the distinction between fundamental and applied knowledge can be overstressed, and that he knew nothing more impressive in the history of the development of human thought than the advances that have been made by a constant interplay between abstract analysis and the attempts to solve particular problems. Assuming that the productivity of applied scientists and development engineers is the same everywhere, Mr. Meier concludes that the United States will benefit about three times as much from current British research as does the whole sterling area; and this judgment takes no account of the fact that shortages of materials, instruments and imperfect organisation make the productivity of applied research in Great Britain considerably lower than in the United States.

Other considerations have also led Mr. Meier to the conclusion that British fundamental research is of far more value to the United States than it is to the sterling area, although, in spite of the elegance of the contributions of British science, they make little difference to the massive economy of the North American continent. Most fundamental research, he suggests, is of the sort that, if it is not done this year, would be done elsewhere in a few years. He claims, indeed, that the highest class of British fundamental research, ordinarily measured by the originality of conception and the reproducibility of results elsewhere, works to the detriment of the trade balance between the sterling areas and the hard-currency areas, and that its marginal value, as it is at present organised, is very negative, being probably between two or five times the total marginal cost of salaries, equipment and overheads.

Mr. Meier admits that this judgment is based upon the experience of one individual, and his conclusions are unlikely to pass without challenge. Nevertheless, he states that he has failed to discover a single instance, except perhaps in the jet project as a whole, where British development of their own fundamental research would bring a substantial reward in terms of foreign markets or rights. The view that very little of the fundamental research in Britain is relevant to the existing capacity to apply it so as to benefit the home economy, although much of it is relevant to applied research carried out in the rest of the world, is indeed consonant with Sir Henry Tizard's view, expressed in his presidential address to the British Association in 1948, that it is not the general expansion of research in Britain which is of first importance for the restoration of its industrial health but the application of what is already known.

What follows from Mr. Meier's analysis, if sound, is not so much the conclusion that there has been too great an outlay on fundamental science and too little in the applied area, as an implied criticism of the direction of research. Prof. Edwards, in his study of co-operative research associations, avoided any discussion of their inherent capacity to select the right targets. Mr. Meier raises that issue over the whole field of fundamental and applied research, whether conducted by Government research stations or private industry or the universities, and he gives point to his criticism by suggesting new directions for British research and the criteria for choosing the type of programme he advocates. Broadly, he suggests that, by taking advantage of the excellencies and minimizing the deficiencies of both fundamental and applied research in Britain, this section of the economy should be eased into a position where opportunities opened up by fundamental research in other countries are grasped as rapidly as other countries borrow from British findings.

The concrete examples of fields and problems which Mr. Meier suggests, such as jet research, food technology, textile fibres and garments, and metallurgy, are of less general interest than the criteria he indicates for selecting programmes. The field should be such, in his view, that rapid advances can be made with theoretical science, and it should draw upon indigenous resources. It should fill a recognized need and aim at a sterling market as well as export outlets. The overall use of the developments should be very wide so that there are good chances for extensive growth of the newly founded industries; but expansion of a heavily subsidized industry or social service should not be involved unless it is clear that such losses are easily recouped. Research should be so gauged that the first returns can be realized within five to fifteen years. The effort needed to achieve supremacy in a specific avenue of research should not require a major portion of the local talent in this field, since a large share will be needed to handle routine improvements of existing products and seek new opportunities.

What Mr. Meier advocates is primarily a change in the organisation of research, and his paper is a challenge to constructive thought, independently of the extent to which his opinions are accepted. He recognizes clearly enough that the change in organisation and the selection of programmes must be made from within, by those who understand intimately British capacities and susceptibilities. He is aware, too, of the difficulties presented by staff position and particularly by the shortage of technologists—a position which, to say the least, is unlikely to be eased by the fresh demands for defence research foreshadowed in the defence debate on July 26. But, for an American, Mr. Meier is singularly free from the inhibition of government direction which has characterized post-war discussions in the United States of the organisation of research.

It is interesting to put Mr. Meier's conclusions alongside some of the conclusions recorded in the third annual report of the Advisory Council on Scientific Policy*. The Council's study of the reports of the committees of inquiry set up by the Ministry of Labour's Technical Personnel Committee into the supply and demand for qualified men of science and engineers has led it to conclude that, in general, university departments have expanded sufficiently to satisfy the prospective demand, save that continuing shortages are expected of chemists and

* Third Annual Report of the Advisory Council on Scientific Policy, 1949–1950. (Cmd. 7992.) Pp. 18. (London: H.M. Stationery Office, 1950.) 6*d.* net.

chemical engineers. Nevertheless, it thinks that Britain should at least maintain the level of output of science graduates which has resulted from implementing the policy advised by the Barlow Committee; and this policy is mainly proposed because the Council believes that, if British industry is to improve or even maintain its present position in the world, it must employ more men of science and engineers both in the conduct of pure research and, still more, in its application.

The Advisory Council refers, in particular, to the desirability of appointing men of science with administrative ability more extensively to leading executive positions, as well as to the use of scientific workers of lesser calibre in a wider range of technical posts. Nevertheless, the Council has reached no conclusion as to the numbers of higher technologists who are required or can be usefully absorbed by industry. On the man-power side, its sole recommendation is that, as soon as the resources, material and human, can be employed without detriment to the work in applied science which the universities are already doing, it would be prudent to establish one or two colleges of applied science, with suitable governing bodies of their own but fitted into the university system, as an addition, and not as an alternative, to the facilities already provided by the university departments of applied science.

Much nearer to the main theme of Mr. Meier's article, however, are the comments of the Advisory Council on a report submitted to the Lord President of the Council by Sir Ben Lockspeiser on the organisation and administration of the Department of Scientific and Industrial Research. Sir Ben Lockspeiser had been asked to consider how best the Government could "ensure the fullest application of scientific knowledge to the solution of the problems of productivity and economic development". In his report the main objectives of the Department are defined as, first, to ensure that the applied scientific research carried out by the Department is at all times related to the economic problems confronting Great Britain, and that the scientific resources of the Department are applied to those problems the solution of which would most assist the national economy: second, to ensure that the resources of the Department are used so as to make the maximum contribution to improving the efficiency of industry, particularly in relation to productivity, new products and new processes; and third, without subtracting from the responsibilities of production departments and nationalized industries for development, to exert its maximum influence in securing the effective application of the results of its researches.

The Advisory Council's own discussions are concerned mainly with the effectiveness of the research work for the manufacturing industries, whether this is carried out in the Department's own establishment or by the industrial research associations. It concurs in the view that the expansion of research within the manufacturing industries is more important at the present time than the expansion of industrial research by the Government. This view is subject to the qualification that there are many branches of industrial research, such as the maintenance of standards of measurement, which can be effectively and economically advanced only in a central establishment. Some form of centralized research is essential for the many manufacturing industries composed of a large number of small and scattered firms, while there are in most fields of investigation problems the generality of which is such that, though their solutions are essential to the progress of research and development in industry, they are most effectively handled in some central organisation which is at the service of industry.

The Advisory Council's report gives no indication that the particular directions in which research should be prosecuted, or the balance between fundamental and applied research on which Mr. Meier focuses his criticism, have been brought under consideration. It would appear that, for all the Advisory Council's agreement with the view that industrial research, in order to be fully effective, should be carried out by industry itself in close touch with development and production, it is satisfied that no method of enabling firms to undertake collectively research which they would be unable to conduct individually has yet been suggested which is better than that of the research associations. The Council recognizes, however, the need for the critical examination of programmes, with a view to the selection for special attention of items most likely to lead to important practical advances, and would deplore any spirit of complacency regarding the utilization of scientific research in Great Britain.

The inquiries which the Advisory Council has conducted during the past year have, however, left it optimistic about the present condition and future prospects of British science. It does not discuss the particular points which Mr. Meier has raised regarding the place of science in the national economy with reference to the competitive position with the hard-currency countries; and it is satisfied that, if British scientific workers continue to lead the world in the originality and importance of their discoveries and if in future the technology proves adequate to the science, then the conditions of prosperity will be fulfilled. To the extent to which this report admits that any success must depend upon the ability to meet competition by applying scientific knowledge more successfully than one's rivals to the industrial processes by which raw materials are transformed into manufactured goods, the Advisory Council recognizes the force of Mr. Meier's contention as to the extent to which broad economic considerations should determine the selection of programmes and targets in industrial research. Mr. Meier has raised important issues, and, if his answers are not altogether convincing, it is to be hoped that later reports from the Advisory Council on Scientific Policy or from some well-informed authoritative body will deal adequately with the questions he has raised. This fresh challenge to a reassessment of the general direction and distribution of the research effort in Britain from the economic point of view, and not least that of the industrial research associations, is bound to be powerfully enforced by the further

stringencies in regard to scientific and technical manpower and materials which will be the inescapable consequence of the new defence programme to which Great Britain has now been driven.

FUNDAMENTAL INDUSTRIAL RESEARCH

Phenomena, Atoms and Molecules: an Attempt to Interpret Phenomena in terms of Mechanisms or Atomic and Molecular Interactions.
By Irving Langmuir. Pp. xi+436. (New York: Philosophical Library, Inc., 1950.) 10 dollars.

AT the end of this book is printed a list of the 215 papers which Dr. Irving Langmuir has written, alone or with his collaborators, since 1906. With few exceptions, all are first communications of the results of original research and deal with what has come to be known as 'fundamental' science. As the creator of the subject of surface chemistry, Dr. Langmuir was awarded a Nobel Prize in 1932, and men of science the world over have honoured him. This book, which collects together twenty of his chief papers in their original form and gives a complete bibliography, is a testimony of his eminence.

The bibliography groups the two hundred-odd papers into the following eight sections: general topics, scientific research, philosophy of science, incentives in science and in industry, and scientific education; structure of matter, of molecules, atoms, crystals, proteins, and ferromagnetic materials; conduction, convection and radiation of heat, diffusion, evaporation in vacuum and in gases, and gas-filled incandescent lamps, etc.; mechanism of chemical reactions at high temperatures and low pressures, and catalysis; high-vacuum phenomena, vacuum pumps, electron emission and space-charge effects; electric discharges in gases, especially at low pressures; surface chemistry, adsorption, surface tension, monomolecular films, and biological applications; meteorology and related fields, aviation, oceanography, turbulent motion of water and air, submarine detection by use of the binaural effect, precipitation static and icing of aircraft.

This record, admirable though it be, is not the uniquely remarkable feature of Dr. Langmuir's career. What is surprising is that all this fundamental work was done in an industrial research laboratory. It could not have been done in a British industrial laboratory during these past forty years, and I doubt very much whether it could be now. It would be misleading to argue from this one exceptional case that American industrial research is more imaginative than British and allows greater freedom to its workers. In both countries the industrial laboratory is all too often merely called upon after trouble has occurred and is not encouraged to think up anything new. There are, of course, magnificent exceptions, but the great majority of industrial scientists are concerned with matters only after lack of knowledge of them has caused difficulties. The real truth of the matter is that it is regrettably rare in either country—or elsewhere, for that matter—for a large concern, once having picked a good man, simply to leave him to follow his bent.

"During these first few years", says Dr. Langmuir, "while I was thus having such a good time satisfying my curiosity and publishing scientific papers on chemical reactions at low pressures, I frequently wondered whether it was fair that I should spend my whole time in an industrial organization on such purely scientific work, for I confess I didn't see what applications could be made of it, nor did I even have any applications in mind. Several times I talked the matter over with Dr. Whitney, saying that I could not tell where this work was going to lead us. He replied that it was not necessary, as far as he was concerned, that it should lead anywhere". This was during 1909–12. Not the least interesting parts of the book are those in which Dr. Langmuir describes how he came to do a classical piece of research and what applications eventually sprang from it. The General Electric Co. of America has presumably had no reason to regret its broad-minded and open-handed attitude.

There is still, and not only in Great Britain, an insufficient appreciation of the importance of the genuine discoverer within industry. It is generally felt in Britain that fundamental research can be left to the universities—indeed, many firms back their faith in them with substantial and conditionless money payments. It is not so much nowadays that industrialists do not believe in fundamental science but that they elevate it beyond their reach. While university 'dons' are treated with exaggerated respect as high priests to be propitiated and occasionally consulted, their own scientific employees are kept in their proper subordinate place. I think the fact of the matter is that the traditional British business man is rather frightened of science; he knows now (rather belatedly) that he has to have it, but the way he intends to get it is very often like this. It would never do to have a man pursuing truth for truth's sake on the firm's own premises—it would unsettle everyone and make things difficult to run. Genius is always an awkward bedfellow.

If one adopts a conservative attitude, this is a perfectly reasonable point of view. The man of science is paid to improve the products, to increase production and lower costs—nothing more. If anything a little more fancy is needed, one can always consult a university professor.

But this is not the way that whole new industries are built, nor, fortunately, is it the universal custom. The more progressive and less traditional the industry, the more intelligent the way in which scientific workers are used within it. One cannot help feeling, however, that we have still to discover the technique of carrying on pure research side by side with the development and application (if any) of its fundamental discoveries. Science is universal, and it is stupid to separate one aspect from another.

In that spring of the post-war world, when men optimistically planned the future, it was indeed often enough said that scientific research was vital to the nation's progress. Later, the dismal pressure of events led, as usual, to a more hard-headed appraisal. What is needed, we are now told, is the translation into industrial practice of already known results. While there can be no doubt that our immediate problems of production should be viewed in this light, it would be a disaster if, thereby, there occurred a reaction against research proper in the industrial field. The future greatness of Great Britain will not lie in a mere routine application of established scientific fact. This is the lesson to be learnt from Dr. Langmuir's book.

D. P. RILEY

COMPANY HISTORY IN THE AMERICAN CHEMICAL INDUSTRY

American Chemical Industry

Edited by Williams Haynes. Vol. 6: The Chemical Companies. Pp. viii+559. (New York: D. Van Nostrand Co., Inc.; London: Macmillan and Co., Ltd., 1949.) 10 dollars; 75*s.* net.

ALTHOUGH it is not a common practice in publications comprising a number of volumes to preface each volume in such a way that the reader may know the number of volumes to expect and may visualize the broad plan of the work, this has been done to advantage in a number of such publications, and it is a great pity that Mr. Haynes did not so preface this or any other volume of his series of six books on the "American Chemical Industry". It is learned that Vols. 2, 3, 4 and 6 have been published so far, but not Vols. 1 and 5, although Vol. 5 is promised for the early future.

Vol. 6 consists of the histories of 219 American chemical-manufacturing corporations that have been edited "not to uniformity, but to strictly factual, almost encyclopedic form". For this reason alone, the volume is not one to be kept on the book-shelf for occasional light reading; but, as a book of reference for information about the principal members of the industry, it has a fund of detail. The information should be completely reliable, as the histories have been written by the companies themselves and have only been edited with the object of rationalizing length, style and content.

Naturally, in these modern times of rapid development, of newly formed companies and of amalgamations and mergers, the reader with a taste for history is more interested in the older companies that have developed, under the direction of individual enthusiasts, from small drug-stores or from back-garden factories to large business concerns still bearing the names of their founders. It is interesting to dissect the 219 companies described in this volume and to discover that two-thirds of them were founded only during the past fifty years, that 28 per cent originated during the period 1850–1900 and that only 7 per cent came into existence before 1850.

These figures are not exact because some companies, founded in one period, may have roots in a much earlier period under a different name and possibly in a different country. For example, Arnold Hoffman and Co., Inc., holds the longest record of continuous service in the textile industry, but only under this name since 1900, whereas the founders, Benjamin and Charles Dyer, started their small wholesale drug store in 1815. Another well-known firm, Merck and Co., Inc., and its predecessor companies originated in 1818, but the business in the United States under the name Merck only dates back to 1891. The origin of the firm of E. Merck, however, was the seventeenth-century pharmacy "At the Sign of the Angel" in Darmstadt in 1668, which business has remained in the Merck family for more than 280 years. The famous du Pont company, associated with explosives for many years, started shakily in 1802, heavily in debt and with explosions destroying part of the mills, but by 1945 its 61,000 employees had produced the stupendous total of 4,500 million lb. of military explosives for the Second World War. Colgate–Palmolive–Peet Co. can be traced back to Colgate and Co., manufacturers of soap and candles in 1806. Devoe and Reynolds Co., Inc., is sixth on the list of the oldest American business firms in continuous operation since their inception, being the outgrowth of a small New York business in paints and oils established in 1754.

However, this is only selecting a few of the older and therefore the more interesting company histories. The others, not so old but none the less interesting, are here to see, recorded in strict alphabetical order and fortified by two full indexes of names and products respectively.

PROBABILITY

The Theory of Probability

An Inquiry into the Logical and Mathematical Foundations of the Calculus of Probability. By Prof. Hans Reichenbach. English translation by Ernest H. Hutten and Maria Reichenbach. Second edition. Pp. xvi+492. (Berkeley and Los Angeles: California University Press; London: Cambridge University Press, 1949.) 12.50 dollars.

THE German edition of this book has had a considerable reputation; substantial revision has been done for the translation. It begins with an elementary account of symbolic logic and a discussion of the axioms of probability theory; the meaning of the subject-matter occupies most of the rest of the book. Probability is defined in terms of the Venn-Mises limiting frequency. The first problem is to show that this satisfies the axioms, and it is to the author's credit that he recognizes that this is desirable. He does it, but does not appear to see the magnitude of the price that he has to pay. It is well known that even for a random series the limit cannot be proved either mathematically or experimentally to exist; and the author does not assume its universal existence. He finds then that, to prove either of the addition and product rules, it is necessary to assume two limits of this type to exist. Thus, any development of the theory must rest on a complicated substratum of existence postulates, which are asserted for the cases considered but not as always true; hence, in any specific application it could be objected that at least one of the limits concerned may not exist and that consequently nothing relevant to that application has been proved.

The author ridicules the alternative that probability is a primitive idea representing a degree of rational belief and exists as a relation between any pair of propositions. His argument against it, when stripped of rhetoric, seems to reduce to "A lot of beliefs are irrational; therefore there can be no theory of rational belief". He does, however, investigate seriously a "many-valued logic", which appears to be the same thing. The general postulate does guarantee that any hypothesis can be tested by means of the theory when relevant data arise; Prof. Reichenbach's caveats serve only to restrict the scope of scientific method without even specifying the cases where it is not applicable.

The principle of inverse probability is proved subject to the restrictions made by the author—the prior probability is required to be based on previous knowledge, as in some statements in Karl Pearson's papers—but he fails to see that this would imply an infinite regress (cf. Bertrand Russell's

"Human Knowledge"). He makes the usual onslaught of advocates of frequency theories on the "principle of indifference", the function of which was to state ignorance and give the applications a possible starting point. He even states that no modification that would meet one of his difficulties has ever been suggested—in fact, I gave one in 1931, and modifications for other cases have been suggested at various times since 1919.

The book is difficult to read; for example, "theorem" and "axiom" appear to be treated as synonymous on p. 58, and there are far too many forward references. However, some of the comments are very apt. To some extent they overlap those in Bertrand Russell's "Human Knowledge", on which I comment in a forthcoming paper in *Mind*.

There is abundant work to be done in probability theory, and philosophers can make and have made important contributions. However, these contributions will be better when more philosophers find time to attend to constructive developments in the rational belief theory within the past thirty years.

HAROLD JEFFREYS

THE PLANNING OF CAMBRIDGE

Cambridge Planning Proposals

A Report to the Town and Country Planning Committee of the Cambridgeshire County Council. By Prof. William Holford and H. Myles Wright. Vol. 1: Pp. xvi+102+9 plates. Vol. 2: Maps and Drawings. Pp. viii+58. (Cambridge: At the University Press, 1950.) 30s. net.

CAN Cambridge control its own destiny in the face of a multitude of unplanned events which may affect its shape, size and appearance in the coming years? This is the question posed by Prof. W. Holford and Mr. H. Myles Wright in the proposals placed by them before the Cambridgeshire County Council; this body has in its turn to submit next year to the Minister of Town and Country Planning a development plan for Cambridgeshire. The planning of Cambridge, a unique university and market town, is a matter of national interest, and the University, Borough and County are all closely concerned in finding the right solution.

The determining factor in the proposed plan is that the growth of the population of Cambridge should be controlled, the future population not being allowed greatly to exceed the present figure. It is to be hoped that this will meet with no serious opposition. The second feature in the plan is that the centre of the town shall be left essentially unchanged, and that relief from the rapidly growing traffic problem should be found in a scheme of by-pass roads in the outskirts and relief roads in the centre.

One important problem is to induce traffic to keep clear so far as possible of what the authors call the "spine road"—that which starts in the south as Hills Road and ends in the north as Huntingdon Road, changing its name seven times on its way through the town. A relief road from the Histon Road corner at the top of Castle Hill, running nearly parallel to the spine on the east side and rejoining it at the corner of Emmanuel Road, is projected; this road has two unfortunate features which the authors have found it impossible to avoid. It involves calling upon Jesus College to sacrifice private land and amenities, and it crosses Christ's Pieces. The second relief road is on the west side of the spine, continuing a widened Guildhall Street through to the end of Downing Street opposite Emmanuel College; this scheme includes a large car park, which is badly needed. When these streets are completed, it is proposed that the present bridge over the River Cam by Magdalene College shall be closed to vehicular traffic—a further incentive to traffic to avoid using the spine road, even in part, for through movement. These two new roads, with a somewhat elaborate system of traffic circulation by one-way roads, should take care of the more serious traffic problems in the town centre.

Next comes the scheme for keeping heavy through-traffic out of the central portion of the town. An outer ring has two by-pass roads: that to the east leaves the road to Royston, A10, beyond Trumpington and crosses the Cam by a new bridge at Chesterton, swinging round north of the town to join the St. Neot's Road west of Madingley Wood; the other, shorter by-pass road on the west side, proceeds via Grantchester and Coton to the Madingley Road at the foot of Madingley Hill. Parts of these outer by-pass roads belong to a long-term programme. An inner ring road is also projected, of which the western route runs along Chaucer Road, crossing the Cam by a new bridge on to Barton Road, thence northward to Madingley Road, which it crosses just east of the Observatory and on to Huntingdon Road. This road is designed to free the Backs of through-traffic from the Huntingdon Road to the south. One very serious criticism must be made of this plan, and that is the choice of the point where the road crosses Madingley Road.

The public-spirited action of St. John's College, the late Prof. Newall and Trinity College has kept the Observatory clear of buildings on its eastern and southern sides. This new scheme proposes a trunk route, presumably taking heavy traffic with blazing headlights at night, approaching the Observatory directly from the south and passing close to the Observatory grounds on the east side. If the Observatory is to continue to function properly, this inner ring road must be diverted to another crossing point, preferably on the west side of the University Farm. Very little farther distance would be involved for the traffic, and the need to move the Observatory farther away from Cambridge would be avoided. Care should be taken to dislocate as little as possible the experimental work of the University Farm. The very heavy expense involved in moving the Observatory would be obviated. It can be said that in all innocence the planners have selected the very worst point for crossing the Madingley Road with their inner ring road. It will ultimately involve the University in the maximum expense and dislocation of scientific work. It is not too late yet to alter the lay-out of this road and to modify plans for new University buildings not yet erected.

Other points of interest in the general scheme are to be found in the provision of access to the railway station from the east side (though no change is contemplated in its unique platform arrangements) and in the regulation of extensions of building with a refusal to allow further ribbon development and extension to the west. The two attractive volumes containing the proposals bear throughout the hall-mark of the Cambridge University Press, and the fifty-eight maps that illustrate the proposals are enlightening and convincing.

F. J. M. STRATTON

MECHANICS OF THE CONTRACTILE ELEMENT OF MUSCLE*

By Prof. A. V. HILL, C.H., F.R.S.

The Parallel Elastic Component

THIS paper deals with the contractile component of muscle, the part which, when stimulated, can shorten and do mechanical work, or develop a force if prevented from shortening. We shall consider chiefly the properties of skeletal muscle, the striated voluntary muscle of vertebrates. In such muscles, as they occur anatomically in the body, the contractile component is mixed with inert elastic material the presence of which makes the experimental study of the mechanical properties of the contractile element itself more difficult. The contractile units, the striated muscle fibres, are surrounded by a sarcolemma which is strong and elastic and provides most of the resistance to static stretch. At the ends of the fibres are elastic tendons which fuse into bundles and join the muscle to the skeleton. The sarcolemma is in parallel with the contractile material, the tendons in series with it. In the muscle as a whole there is further elastic material in parallel with the fibres. In smooth muscle an almost infinite variety occurs in the distribution of elastic material. At one extreme, for example, in the retractor of the pharynx of the snail or the muscle of the body-wall of Holothuria, a parallel elastic component is almost completely lacking: at rest quite a small load will gradually draw the muscle out to great lengths. At the other extreme, the muscular component of the wall of such hollow organs as blood vessels, the urinary bladder, or bronchi is so intermixed with inert material that its mechanical properties are difficult to evaluate. Some smooth muscles, such as the retractor penis of the dog or the nictitating membrane of the cat, are very similar in their elastic properties to striated muscle.

In order to study the mechanical behaviour of the contractile material proper, at rest or during activity, the complication provided by the parallel elastic material must be avoided. This can be done by employing muscles, such as the snail retractor, in which the parallel elastic component is of negligible importance; but that greatly limits the choice of material and the range of investigation. A better and more general method is to work within the range of lengths in which the force exerted by the parallel elastic component is insignificant. In skeletal muscles with long parallel fibres, for example, the sartorius of frog or toad, or particularly the iliofibularis of tortoise, this range is ample. Within this range the tension at rest is small, and depends on the muscle's previous history of stretch and stimulation. At greater lengths the mechanical properties of the resting skeletal muscle, for example, its load-extension curve and its thermo-elastic relations, are due chiefly to the parallel elastic component. Much research has been devoted to these properties of resting muscle, but its results tell us little about the contractile component itself, and nothing about its active state; such work could better be done on inert connective tissue.

It is fortunate that the range of lengths within which the tension of the resting skeletal muscle is small is physiologically the most interesting (see graph, p. 417). It includes the length at which the greatest contractile force can be exerted, and all the lengths which can occur in the living body. With due precautions, therefore, the effect of the parallel elastic component can be largely avoided.

The Contractile Component at Rest

Of the contractile material itself, the properties at rest can best be described as follows, without any reference to elasticity. A skeletal muscle with long straight fibres, under zero load, can be brought by one or two shocks to a very short length, and there it remains. That its fibres really are short, not merely lying in folds, is shown by two facts: (i) the latent period, that is, the interval between a stimulus and the first sign of contraction, is much the same as at greater lengths; if the fibres, or fibrils, were in folds they would have to take up their slack before being able to exert an external force, and that would greatly increase the latent period; and (ii) if a quick stretch be applied to the shortened muscle it immediately resists, the tension rising rapidly from the start; if there were slack, delay would be evident before the tension began to rise. Now with the shortened muscle attached to a delicate tension recorder, let us gently stretch it, say, 1 or 2 mm. During the stretch its tension rises—more the faster the stretch. As soon as the stretch ends, the tension begins to relax; but not to zero—the final value is small but measurable. Let us stretch it again the same distance. Once more the tension rises, to fall again after the stretch to a small but measurable value. The process can be repeated until at greater lengths the elastic resistance of the parallel elastic component, as its elements become taut, begins to obscure the effect, each successive increment of length then leading to a greater increment of tension from which little relaxation occurs.

If a muscle, shortened by stimulation and then stretched, be released to a length at which it previously showed measurable tension, its tension is now found to be less. The tension at any length depends on the previous history of stimulus, stretch and release. The tension is greatest at any length when the muscle has been stimulated previously at some shorter length and then pulled out, and least when stretched to some greater length and then released. The whole process of stimulus, shortening, stretch and release is repeatable, no permanent change in the muscle being detected. One can think of stimulation as causing a general release, a shaking up, of the molecules or elementary units of the structure, which proceed in relaxation to 'set' in a pattern or distribution appropriate to the final length attained. There they stay, weakly held together by structural forces, until an external force disturbs them.

In a smooth muscle at rest, the tension resisting rapid stretch may be large and easily measured. Directly the stretch ends the tension begins to drop, and Bozler found in the snail's retractor that its rate of fall was the same as during relaxation after an

* Introduction to a discussion on muscle, on July 28, during an International Colloquium on Rheological Problems in Biology held at Lund.

isometric contraction. In most striated muscles at rest the resistance to stretch is rather small, though in some, notably those of the tortoise, it is much greater. When the stretch ends, the tension rapidly falls, but at quite a different rate from the fall of tension after contraction. Indeed, a striking difference exists in the fact that the rate of fall after contraction is greatly affected by temperature, but after stretch practically not at all. Can Bozler's result be true only at the particular temperature he used?

In certain smooth muscles at rest, those unsupported by a parallel elastic component, the contractile material seems to be almost indefinitely plastic and extensible, even under a very small load. A quick stretch is met by a strong resistance, a slow stretch by a small one. In such muscles, apparently, no static tension at rest is possible at any length. In striated muscle, on the other hand, a small but finite tension can be detected down to quite short lengths if the muscle is brought to them by the procedure mentioned earlier. It seems most likely that this small tension is exerted by the contractile component itself, not by the parallel elastic structures; for it is reduced by a stretch followed by an equal release, and remains reduced until the muscle is stimulated again. In any event, the force exerted by the contractile component at rest is small, not more than 1 per cent or so of that during full activity.

The Contractile Component during Activity

When a muscle fibre is excited by a nerve impulse, or an electric shock, a wave of excitation travels along its surface, as the result of which the interior of the fibre passes temporarily into contraction. When this wave arrives at any point on the surface, it sets up there a change of some kind which travels inwards across the fibre, producing the active state. The physical nature of the wave of excitation, which is always associated with a propagated electric change, need not concern us now: it is presumably the same in muscle as in nerve. The nature of the process by which the contractile state is transmitted inwards from the excited surface is not known; but the time required for the fibre to become fully active is far too short for diffusion of a substance inwards from the surface to be the cause; an event, not a substance, is propagated to the inside, setting in train as it goes the complex sequence of events recognized as contraction.

The unit of muscular activity is the single twitch, produced in response to a nerve impulse or an electric shock. The ordinary picture of a muscle twitch shows a gradual rising phase, a blunt maximum and gradual relaxation. By repeating the stimulus at a sufficient frequency, the resulting twitches can be fused into an apparently smooth maintained contraction, which begins to decline soon after the last stimulus. The gradualness of the development of tension in an ordinary 'isometric' contraction gives an entirely misleading picture of the rapidity of onset of the active state. The form of the isometric myogram is determined by the rate at which the contractile component can shorten against the increasing tension of the elastic component in series with it as that component is stretched. We have to use special devices to avoid this complication. When we do so, the following properties of the contractile material during activity emerge.

(1) The velocity of shortening against a load is greater the smaller the load. The experimental relation between speed and load can be expressed by a family of curves, each for a given length. Over a considerable range of lengths, however, it is given mathematically by the single characteristic equation:

$$(P + a)\, v = b\,(P_o - P),$$

where P is load, v is velocity of shortening, P_o is the maximum force which the muscle can exert (at zero speed), and a and b are constants. In most muscles a/P_o is about $\frac{1}{4}$, so that the maximum speed of shortening (under zero load) is about $4b$. We shall consider this relation again later; it represents the most significant mechanical property of active muscle. It is important to note that P need not be constant; it can vary with time or distance during contraction. The velocity of shortening depends on the load at the moment, and varies instantly as the load varies.

(2) After a stimulus a finite interval elapses before contraction occurs. This is known as the latent period, and the term will be used with its common meaning to cover the time before the first sign of increased tension or shortening appears. By two special methods, however, it can be shown that mechanical changes begin much earlier than this: (*a*) if a rapid stretch is applied during the earlier part of the latent period, the muscle begins to resist stretch from about the middle of the latent period onwards; by the end of the latent period it is resisting strongly; (*b*) by an extremely delicate method employing a piezo-electric crystal and high amplification, it can be shown, in a muscle under initial tension, that the first sign of activity is a slight lengthening, beginning at about the middle of the latent period. This is gradually reversed and merges into the positive phase at the end of the latent period as ordinarily observed. This 'latency relaxation', so called, is not found in muscles under low initial tension. It is not due to an initial increase of extensibility, for the method of quick stretch always shows a decrease of extensibility starting at about the same moment. It is probably due to a slight increase of length, an accompaniment of the extensive molecular change underlying the observed increase of rigidity.

There are two other early signs of the onset of the active state: (i) the heat production begins at its maximum rate at about the middle of the latent period; and (ii) an increase of optical transparency begins at about the same moment.

(3) By the method of rapid stretches it is found that full activity has been developed much earlier than ordinarily supposed. By an appropriate stretch applied during the earliest phase of contraction, a muscle is caused to develop almost abruptly a force considerably greater than the maximum of an ordinary isometric twitch, indeed, about equal to the force of a maintained tetanic contraction. This force is held for a time and then gradually decreases as relaxation sets in. The explanation is simple. The force in an ordinary isometric contraction can be developed only by the contractile component shortening and stretching the elastic component in series with it. This shortening goes on slower and slower as the tension rises, and relaxation has really begun long before this shortening is complete. The maximum tension of an ordinary isometric twitch is reached as a balance between internal shortening and oncoming relaxation. A rapid stretch obviates the necessity of the slow shortening and finds the muscle already in its fully active state.

It is difficult to say how rapid the onset of full activity really is. The fibres of a muscle vary largely in size, and their mechanical characteristics may also

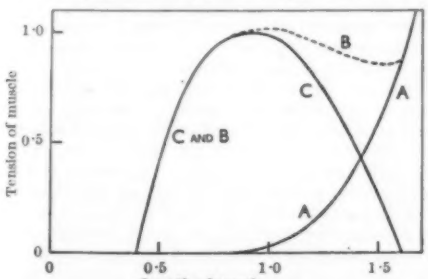
vary. The maximum force could not be developed until the slowest fibres were fully active. Moreover, it may take time for activity to spread throughout the body of a fibre, from the surface at which excitation occurs. It is certain, however, that a muscle can resist stretch with its full tension within about 10 per cent of the time normally required to reach the maximum tension of an ordinary twitch.

(4) After contraction occurs relaxation, in which the original mechanical state is restored. In a contraction under constant load, the muscle shortens and then lengthens again; in a contraction at constant length, the tension rises and then falls. It has long been disputed whether relaxation is an active or a passive process, but the evidence is now decisively in favour of the latter. For example, no heat is given out in relaxation; any that appears is due to mechanical energy converted into heat as the load falls or the elastic elements shorten. Again, as we have seen already, when a muscle with straight fibres is stimulated and allowed to shorten freely, it remains short afterwards, under a slight but measurable tension, with the usual latent period and an immediate resistance to a quick stretch. Moreover, a muscle suddenly released during relaxation does not redevelop its tension; it has become inert. It appears, therefore, that relaxation does not involve anything more than the disappearance of the active state set up by stimulation. Lengthening does not occur unless there is a load on the muscle to stretch it, or unless it is subject when shortened to elastic constraint tending to pull or push it out. The onset of relaxation is gradual, not sudden like that of the active state after a stimulus.

Mechanical Properties of the Active State

The activity of a muscle can be maintained, with a continual expenditure of energy, by repetitive stimulation. Each stimulus then restores the active state to its full value, from which it has declined in the interval between stimuli. By a suitable frequency of stimulation the maximum intensity of the active state can be kept up until fatigue begins to appear. The mechanical properties of the active state can best be studied while maintained in this way. They can be summarized as follows.

(1) The static relation between force developed and length is shown in the accompanying graph. The length marked unity is that of the muscle as it exists in the living body, at rest under standard conditions. At this length the resting tension is small, 1–2 per cent of the maximum during activity. At or about this length the active force of the muscle is greatest, and from this length downwards the relation is simple and unambiguous. At greater lengths, however, the



(*A*) Tension at rest; (*B*) total tension during contraction; (C) 'tension developed' = (*A* − *B*). Length normally in body = 1·0

tension exerted at rest provides an increasing complication. Can we simply subtract the tension at rest from the total tension exerted during activity, to obtain the contribution of the active contractile component? We can under two conditions: (*a*) if the parallel elastic component be supposed to take the whole, or nearly enough the whole, of the resting tension; and (*b*) if it be assumed to run the whole length of the muscle, in parallel with the system made up of the contractile component with its elastic body in series with it. The former condition seems very likely; it is doubtful whether the contractile component at rest exerts, at any length, more than a small tension. The second condition is less certain. In a single fibre, for which the clearest results have been obtained, the parallel elastic component consists of the sarcolemma alone, which is in parallel with the contractile component itself but not with its tendinous ends. Even if the recording system had no significant extension of its own, the extra tension developed during activity must stretch the tendons and so allow the sarcolemma to shorten. But the load-extension curve of the resting fibre, presumed to be that of the sarcolemma, rises very steeply at greater extensions, so that even a small shortening of it, as the tendons are stretched, is bound to cause a certain fall of the passive term in the tension. Thus the extra tension developed by the contractile component during activity exceeds the difference (total tension – resting tension) by some unknown amount, possibly not large, but probably not negligible.

In spite, however, of this uncertainty, the observed form of the relation in the graph probably gives a general impression of the facts not too far from the truth. If so, a little reflexion shows how peculiar a relation it is. Try to imagine an elastic body which exerts a maximum force at one special length, the force diminishing more or less symmetrically on both sides and becoming zero at about 0·4 and 1·6 times that length! This is one of many reasons for not regarding the contractile component of the active muscle as an elastic body. One could devise a system of attractions and repulsions possessing this property, but to locate them in an actomyosin thread might tax one's ingenuity.

(2) The dynamic properties referred to earlier as the characteristic relation between load and velocity are common to all kinds of muscle. Whether the characteristic equation itself applies, with sufficient accuracy to make it useful, to any muscles other than the skeletal muscles of frog, toad and man has not yet been established, but a relation of the general type certainly exists. It was natural to suppose—and for many years it was supposed—that this characteristic relation is determined by the viscosity of the contractile material. The active state was distinguished not only by the power of shortening, or of developing a force, but also by an increase of viscosity, large or small, depending on the muscle and its temperature. The higher the intrinsic speed of the muscle, the lower the viscosity. There was a minor difficulty, in the fact that according to the viscosity theory the relation between load and velocity should be linear, which it was not; but in a system as complex as a muscle, this difficulty need not be insuperable.

A much greater difficulty was that, when a muscle shortened, an extra quantity of heat was liberated which was exactly proportional to the distance shortened, but independent of the speed of shortening; a viscous resistance to shortening could not

provide this relation. If there were really an internal opposition to shortening it had to be constant, like ordinary friction, not increasing with speed like a viscous resistance. Moreover, the amount of mechanical work done in lifting an external load, which could be varied at will by varying the load, had no effect on the heat, provided that the amount of shortening was kept the same. The work plus heat was not constant, as it should have been if a certain amount of potential energy was liberated by the stimulus and then used in overcoming resistance, external and internal. Next, it was found that if a muscle was stretched during an active contraction, a considerable part (under some conditions, the whole) of the work done in stretching it disappeared—that is, it could not be traced afterwards either as heat or as mechanical potential energy. Presumably this work was used up in causing some chemical reaction to go backwards, which in normal circumstances during shortening provided work and heat. No system which included an internal resistance, frictional or viscous, to change of shape could show such relations. The viscous-elastic theory of the active muscle had served its purpose for a long time, it had provoked a variety of new and valuable experiments, but now it must be allowed to die an honourable death.

It is not possible as yet to propose a convincing theory in its place. A striking fact is that the constant a in the characteristic equation between load and speed

$$(P + a)\, v = (P_0 - P)\, b$$

is the same as the constant a of the shortening heat ax, where x is the amount of shortening. This equality, observed in a variety of circumstances, cannot be simply a coincidence. In the characteristic equation, Pv is the rate of doing mechanical work and av is the rate of liberating heat of shortening. Their sum $(P+a)$ multiplied by v—the rate at which energy is set free—is a linear function of the load P. What this simple relation means is not clear, but it is surely pertinent in any theory of the energetics of muscular shortening. The physical framework responsible for the dynamic properties of active muscle must clearly be regarded as coupled mechanically with reversible chemical processes by which energy is supplied in shortening, or absorbed in lengthening. The rate of energy supply is controlled by the tension of the muscle itself. Mechanical coupling of this kind to a source of chemical energy is not so common a property of physico-chemical systems that likely analogies are easily drawn. Its presence in muscle introduces a factor in rheology of which no other example comes to mind.

Structural Pattern of Muscle

It seems pretty clear that the sudden transformation of a resting muscle to its active state must involve a rather fundamental change in the physical configuration of its constituent proteins. The rapid decrease of extensibility following stimulation, and the accompanying ability to shorten and do mechanical work, might imply an extensive alteration in the distribution of electric charge, or of dielectric constant. The examination of such possibilities should not be beyond the power of modern electrical technique. Again, X-ray diffraction methods might throw considerable light on the problem, if equipment powerful enough were available. Optical methods (for example, the comparison of double refraction, scattering or absorption in resting and active muscle, or during shortening and lengthening) might turn up unexpected clues. Possibly also the application of these or other methods to a variety of muscles in a wider range of animals might shed fresh light. Chemical methods are not likely to yield direct results, being too slow and insensitive to follow the rapid transformations that occur during a single contraction; and by repeating the stimulus many times, in order to get measurable quantities, all the processes are jumbled together and their finer details obscured. The contribution which biochemistry can make to the problem is more likely to come from studies of the substances and enzymes that can be isolated from muscle, and an attempt from these to synthesize a working model.

According to the characteristic relation between load and velocity of shortening, the velocity becomes very small as the load approaches the maximum force which the muscle can exert. With loads greater than this we should expect the muscle to lengthen, and so it does. The equation predicts that even under loads considerably in excess of the isometric tension the velocity of lengthening should be small: for example, with $P = 2P_0$, the calculated value of v (assuming $a/P_0 = \frac{1}{4}$) is only one-ninth of the maximum velocity of shortening under zero load. With loads not much in excess of the isometric tension, the velocity of lengthening is actually substantially less than that predicted. With greater loads, however, a different phenomenon appears, the muscle seeming to 'give' or 'slip', just like a wire stressed beyond its elastic limit, or a nylon or polythene thread during 'cold-drawing'. This 'give' or 'slip', however, does not damage the muscle; no permanent effect is produced; as soon as the excessive load is removed, the contraction continues in the normal way.

The same property of active contracting muscle can be exhibited by stretching it at a constant velocity and recording the tension developed. At a very low speed of stretch the tension rises moderately, continuing to rise as the stretch continues; at a higher speed the tension goes higher; it starts to return very abruptly at the end of the stretch. There is, however, a limit to the force with which stretch is resisted: it does not increase indefinitely with speed. Qualitatively, the phenomenon is similar to that observed in stretching a resting muscle, but with much greater forces involved. Direct measurement shows that most of the work done in stretching at high speed appears as heat in the muscle: but the muscle is not altered in the process.

Strength of the Molecular Architecture

We saw earlier why the viscous-elastic theory of the active state of muscle has had to be abandoned. It does not follow, however, that viscous resistance to change of shape is not an important factor in many of the processes described. I doubt whether it is simple viscosity in the classical sense, but many things described as viscous really depend on resistance to change in an organised system, not purely in a random medium. A crystal, without any alteration in the internal pattern of its atoms, can exist in widely different external forms; in passing from one external shape to another, its atoms would have to be largely redistributed in relation to one another. If the process were carried out slowly enough, it need involve no significant change of energy; carried out rapidly, it would in practice require a large expenditure of work. No doubt can exist that in muscle, as in other living structures, a characteristic molecular

pattern is present. It is revealed by X-ray diffraction, by birefringence and by other optical effects. If this basic pattern is the same at different lengths, then a rapid change of length imposed forcibly on the system from outside must momentarily break up the pattern, which later re-forms when left to itself. If records of X-ray diffraction could be made rapidly enough, it would be interesting to see whether the pattern alters or disappears while the length is actually changing, to reappear later. Analogous observations might be made with birefringence.

The forces maintaining this molecular architecture in resting striated muscle seem not to be large: quite small external forces can overcome them if time be allowed. A change of external shape provokes an internal resistance, increasing—but only up to a certain limit—with the velocity of change. Pure viscosity could provide no such limit. In the molecular architecture the structural forces might well be different from point to point. A small external force might overcome the individual internal forces one by one, and the change of shape would be slow. A larger external force would overcome the internal forces at a higher level, and therefore more frequently, and the change of shape would be faster. With a rapid change of shape the external force would have to be great enough to overcome the internal forces at their upper limit; however rapid the change of shape, this would provide the limiting resistance.

Some smooth muscles at rest increase indefinitely in length, though very slowly, even under a very small external load. The lower limit of the structural forces in their molecular architecture is apparently very small. The strong resistance, however, to more rapid stretch shows that their mean value is quite high. Can we extend this idea to explain the phenomena of tonus, often described but never assimilated to the other properties of muscle? Let us imagine that the lower limit of these structural forces, holding the molecular architecture together, can be raised by physical influences or chemical agents. The presence of such influence or agent might, so to speak, lock the structure at some particular length or shape, from which only a large force, or a stimulus of some kind —perhaps an ordinary contraction—could unlock it. Many speculations of that kind have been published from time to time, over many years. They spring naturally to the mind of anyone acquainted with the comparative physiology of muscle. The difficulty has been to give them some kind of physical or chemical basis, to tie them on in some way to other properties of muscle. The natural tendency, since they could not be fitted in, has been to disregard the phenomena of tonic-maintained contraction. When not disregarded, tonus has generally been explained as the tetanic response of an extremely slow muscle—as it probably often is. But there are muscles in which a strong prolonged contraction can be broken up quickly by a stimulus—which is not what happens to a tetanus. Something still is missing: but what? Can this idea of a molecular architecture of variable, or adjustable, strength bring all the facts into one picture?

These may be wild speculations, but at least they started off from real properties of real muscles, and perhaps they give some hope of fitting all the properties of muscle into a single intelligible scheme. A cynic once remarked that the only thing that mankind can do is to move things. It would be pleasant to be able to add that at any rate he can understand how, if not why, he moves them.

THE INTERNATIONAL BOTANICAL CONGRESS AT STOCKHOLM

By Dr. J. RAMSBOTTOM, O.B.E.,
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THE seventh International Botanical Congress was held at Stockholm during July 12–20. The first of the present series was at Paris in 1900, and it was then decided that future congresses should be held quinquennially. The projected fourth congress to be held in London in 1915 never took place: no international congress was possible at that time, and British botanists, influenced by an excess of courtesy or caution, later decided that London should give up its claims, and arranged an Imperial Botanical Conference in 1924. American botanists, having obtained general approval, stepped into the breach and held a Plant Sciences Congress at Ithaca in 1926. This was very successful, and, though it was not rightly one of the series, its far-reaching effects led to its being included. The detailed preparations for the seventh congress, which was to have been held at Stockholm in 1940, were well under way when war again intervened. It gave general satisfaction when the Swedish botanists proposed to carry on with preparations for a congress in 1950; without their sacrifice of time and energy there would have been great difficulties, some obvious, some recondite, which would have needed much consultation and compromise to resolve. It was high time that botanists of all nations met, and the material success of the recent Congress was due to the realization of this; but it should not be overlooked that the splendid opportunity was the result of the determination of Swedish botanists to do whatever was possible to achieve it. To read the list of names of the Swedes who were directly concerned in the preparations makes one realize that practically every Swedish botanist must have had the conference well in mind for the past two years or so.

The first plenary session was held in the magnificent concert hall, H.R.H. the Crown Prince of Sweden, patron of the Congress, making the opening speech. He is known in Sweden as a keen amateur botanist, horticulturist and archæologist, and his remarks had a personal touch, particularly when he commented upon specialization untempered by a wide outlook. Prof. C. Skottsberg, president of the Congress, in his address said that "never before did a country with a population so small as that of Sweden act as host to an international conference equal in size and scope to this botanical congress. Our membership figures, well over 1,450, and distributed among fifty countries, leave all former ones behind". After commenting on the years of devastation and the difficulties of free international scientific co-operation, he spoke of the timidity which had been felt by the Swedes when they decided to renew their efforts to bring botanists together. "Our Congress is international. All countries were asked to join". Several countries were not able to join because of financial stringencies; but a small number of delegates were financed by Unesco. "Another matter of concern is that there were, in other countries, distinguished botanists who wanted to come and who *could* have come, but were prevented from coming by a political system which believes in self-sufficient isolation as the proper road to progress. For this

reason, several old friends and colleagues who were among the first to apply for membership have been obliged to withdraw their applications. It is gratifying that the Soviet Union has found it possible to send a delegation. Unfortunately, the official announcement with the names of the delegates and the titles of their papers reached us so late that the Congress Programme was in the press".

The effect on botanical science of the War in several countries was commented on, and the president mentioned incidentally that "the British delegation, including men and women from all the Dominions and some of the Colonies beyond the seas, is the largest of all".

Most of the speech was in English; but parts were in French, German and Spanish, doubtless a surprise to those younger botanists who had had no previous experience of the linguistic abilities of Scandinavian and 'Benelux' countries.

The session ended with an address by F. T. Wahlen, of the Food and Agriculture Organisation of the United Nations, on "Botany and World Husbandry". It was a clear summary of the relation between botanical science and world energy. The first 'joint inventory' had been made last year at the U.N. Scientific Conference on Conservation and Utilization of Resources. So far as our food reserves are concerned, we are living on a bank account without a balance sheet and with no possibility of assuring the future rate of use. From an overall point of view there can be no doubt that the plant scientist holds the key to the greatest treasure-store humanity possesses: how we make use of the material and ideal riches invested in the plant cover of our planet will be one of the decisive factors in the welfare and happiness of mankind. The problems we have to face call for sound co-operation between all those who study any aspect of plant life.

Doubtless this address was given so important a place in the programme because of its importance in directing the attention of an international gathering of botanists to the wider aspects of their studies. Unfortunately, however, it did not receive the attention which it merited, for members were worried by a nice calculation of the time necessary in Stockholm to obtain lunch apd get to the University, where the sectional meetings began at 1 o'clock. The purpose of the lecture would have been much better achieved if it had been arranged for the evening: moreover, with lantern slides it would doubtless have had an appeal to the general public.

The proceedings of the Congress were divided among fifteen sections: Agronomic Botany (president, F. T. Wahlen); Cytology (president, C. D. Darlington); Experimental Ecology (president, W. H. Pearsall); Experimental Taxonomy (president, T. H. Goodspeed); Forest Botany (president, D. V. Baxter); Genetics (president, Ö. Winge); Morphology and Anatomy (president, A. J. Eames); Mycology and Bacteriology (president, J. Ramsbottom); Nomenclature (presidents, E. D. Merrill, T. A. Sprague); Palæobotany (president, H. Hamshaw Thomas); Phytogeography, with Comparative Ecology (president, C. Troll); Phytopathology (president, E. C. Stakman); Plant Physiology (president, F. G. Gregory); Taxonomy: Cryptogams (president, F. E. Fritsch); and Taxonomy: Phanerogams (president, H. J. Lam).

The sectional meetings were held on Wednesday afternoon (July 12), the mornings and afternoons of Friday, Monday, Tuesday and Wednesday, and Thursday morning. The meeting rooms were not too widely dispersed; but it was impossible, even if without responsibilities, to listen to more than an occasional paper in a section other than the one in which individual particular interest was centred. There are proposals to increase the number of sections at future congresses; but this will tend to make matters worse and lead eventually to the splitting off of sections or groups of sections into specialist congresses. It is in the best interest of botanical science that its several parts should remain as closely interwoven in theory and in practice as they are in fact.

Although there were fifteen sections, there was frequent grouping of subjects important to more than one section; indeed, joint meetings of even four sections were not exceptional.

The arranging of the programmes for the several sections must have been very laborious. The original intention was to decide on special subjects and invite selected botanists to contribute. To them an average of thirty minutes was allotted; those who offered papers were allowed fifteen minutes. Some of the former were summaries of modern lines of investigation and were most valuable in bringing forward knowledge of much work carried out on special aspects of botany through the years of intellectual obscurity. Perhaps more latitude was given to the papers which were offered than will be advisable at future meetings, for some of them dealt with results already published. In the present state of intercommunication there is justification in directing attention to work which has apparently been overlooked; but in more normal times it must be assumed that publication has been effective in its purpose. This would scarcely deserve mention except that the practice is not unknown elsewhere, and occasionally has aspects which are not entirely without motive, as well as overcrowding programmes so that comment, valuable criticism and interesting discussion have to be sacrificed to keep rigidly to a time-table.

The general level of communications in the sections was commendably high; but none seems to have been of that originality and eminence that calls for special comment. Everyone seems to have been satisfied with the section in which he was particularly interested; but after much inquiry I was unable to find that other sections differed from that of Mycology and Bacteriology, where the general accounts of special aspects given by invitation to form an introduction to their more detailed consideration were the most stimulating; but many important facts and points of view cropped up with unexpected frequency in the short communications: the occasional non-appearance of an advertised speaker, where there was no written communication, provided much-needed time for discussing these results and getting them in some sort of perspective.

Having regard to the lapse of fifteen years since the last International Botanical Congress, those responsible for arranging the programmes accomplished a very difficult task in a most excellent way. Much of their basic scheme will have to be followed in future congresses if some sort of unity is to be retained. The ground has been cleared, and we should look forward to making the best use of the opportunities international congresses give for the discussion of fundamental problems which have arisen or have been materially influenced by research in the years between the meetings.

No useful purpose would be served by listing the numerous subjects which were discussed, especially as abstracts of all communications are to be published in a few months.

Exception, however, may be made for the Russian communications, as they give some indication of a line of approach to international botanical matters. A demand was made for time for communications, which I understand came so very late that normally it would have been refused. It was in the best interests of international scientific relations that the Swedes decided that an exception should be made; I think the majority of the congress members approved of their decision.

The authors and titles of the communications were: I. E. Glyschenko, "Hybridisation of Plants by Grafting"; K. S. Suchov, "The Directed Influence of Phytopathogenic Vira on Plants"; N. V. Turbin, "New Experiments elucidating the Nature of Fertilization"; V. N. Stoletov, "The Nature of Hybrid Plants"; P. A. Baranov, "Cultivated Plants during Extreme Conditions of Life"; V. N. Soukatchev, "On the Exploration of the Vegetation of the Soviet Union".

Obviously there was great excitement about the first communication, and the hall was crowded. There was a feeling that the meeting was to be used as a platform for something other than a discussion of scientific facts. It is to be regretted that most of those who interrogated Dr. Glyschenko asked questions designed to cause embarrassment, through his ignorance of the minutiæ of experiments which serve to confirm the more generally accepted views, rather than to elicit critical information about the scientific facts upon which the Russian official dogma is based. Nothing was gained by ridicule—except waste of time, for the meeting dragged on until 12.30 a.m.

One point that needs to be stressed is that there should be some standardization of the size of lantern slides. I understand that all who wished for a lantern were asked what size of slide they were bringing. The almost invariable answer was "the usual . . . size". This resulted in the loss of time and probably of temper, when, as happened at the first meeting of one section, five different sizes of slides were produced, which necessitated the use of three different lanterns. A paper given at an international congress, even if it does not require the making of new slides, should be regarded as of such importance as to warrant the demand that they should be of a specified size or sizes.

The official excursions and visits, apart from those arranged for ladies and other 'passive' members, began after Wednesday's opening sectional meetings, when buses were taken to the Royal Palace at Drottningholm, where H.R.H. the Crown Prince, deputizing for H.M. the King, received the guests. Unfortunately, the day was overcast and rather cool, and the full beauty of the "Versailles of Sweden" was not seen, though, as rain kept off, refreshments were served in the open. The famous theatre provided many with a resting place from which they could admire the remarkable stage.

The following day was spent in exploring the Stockholm Archipelago. There was a general trip on a pleasure steamer; but there were several others labelled for specialists, where the transport was by naval minesweepers reached by landing craft. Swedish botanists as a whole have an exceedingly wide knowledge of the constituents of their flora, and the various leaders thoroughly enjoyed discussing problems of distribution, habitat relations and succession of all plant groups.

The second plenary session was on Saturday morning. After the necessary business two interesting addresses were given. Dr. F. Verdoorn first spoke "On the History of International Botanical Congresses" from that of Brussels in 1864, where, as throughout the nineteenth century, horticulture played a prominent part in them, up to and through the present series of purely botanical ones. Dr. F. W. Went then spoke on "The Effects of Climate on Plant Growth and Distribution". This was an account of the work being carried out at the wonderfully designed and equipped laboratory at Pasadena, California, illustrated by colour photographs. Afterwards visits were made to the Forestry Research Institution, the Natural History Museum, and the Bergius Botanic Garden, which are in fairly close proximity to one another, and to the Royal Swedish Academy.

Sunday was spent at Uppsala. A start was made from Stockholm at 9 a.m. and many did not reach it again until 2.30 a.m. There were five parties, with their distinguishing letters, which were supposedly grouped according to particular interests; but some whimsicality seemed occasionally to have intruded itself. However, all were impressed by what they saw of the facilities for research in the several institutions, and the enthusiasm and ability of those engaged in it.

After lunch there was what might be styled a Linnæan pilgrimage. First there was a visit to the old University Botanic Garden, now laid out again as Linnæus arranged it, and his house with many of his possessions. Then a drive to his country estate at Hammarby, which probably never before had so many visitors at one time, with the two eminent Linnean authorities, Prof. R. E. Fries (president-designate of the 1940 Stockholm Conference) and Col. A. Uggla as guides. Finally, many went to the fine old cathedral to see Linnæus's tomb and memorial, which had a small floral tribute at its base tied with ribbons of the national colours. The veneration with which Linnæus is regarded by Swedish botanists was understood and appreciated by many who, until then, had been restricted to a modern text-book outlook. To those who had had the good fortune of a previous visit to Uppsala the blending of the ancient and modern gave renewed delight.

In the evening there was a dinner in the great hall of the ancient castle, with a speech of welcome by the Governor of Uppsala. After dinner there was dancing before the return to Stockholm.

Apart from private dinners, luncheons and cocktail parties at some of the embassies, the only remaining general festive occasion was a farewell party in the famous town hall at Stockholm on the last night. The final plenary session at the concert hall preceded this. It was there agreed that future International Botanical Congresses should be held alternately in Europe and out of Europe at three- or four-yearly intervals after consultation with the International Union of Biological Sciences, and that the next should be at Paris in 1954.

It was further agreed that a Bureau of Plant Taxonomy and Nomenclature should be set up under the auspices of the International Union of Biological Sciences, and that an International Society of Plant Taxonomy should be established.

After the main business, a large floral wreath, to be placed on Linnæus's memoral at Uppsala, was

presented to the president by Dr. E. D. Merrill on behalf of the foreign members of the Congress who, as "guests in a hospitable country", wished it to be accepted as a token of all that the Swedish botanists had done in ensuring that the Congress would be a success, and of their admiration of their illustrious countryman. Following this, representatives of the various delegations made speeches of thanks. The last in alphabetical order was the U.S.S.R. representative, who informed the meeting, in the characteristic Russian way, that Josef Stalin had decided that the chief aim of botanical studies was to convert plants to man's use ; and that the president in his address had been mistaken in assuming that certain intending members had been prevented from attendance—these botanists of free democracies had decided that the expression of their views could safely be left to the Soviet delegation. Lest there should be misunderstanding of this strange assertion it was stated three times in different words. It was stupid in the extreme, however, to think that anyone was deceived by such statements, for there had been no attempt to arrange that papers which had been sent in by those botanists were presented at the sectional meetings. The introduction of political polemics of this kind was an innovation at once stupid and ineffective in such an assembly. It was announced that the Russian delegates were to lay their own wreath on Linnæus's memorial.

Before the Congress proper there were some excursions for specialists and a Conference on Palynology. But the Section on Nomenclature spent a full week ploughing through a synopsis of the proposals put forward since 1935. Fortunately, a meeting of specialists held at Utrecht in 1948 had given an opinion on many of them, and thus broken the back of much discussion. It was heavy going, however, to work through 238 printed pages, and there was little of the evenings not occupied with committees. It was not possible to complete the discussions before the full Congress, and three additional meetings had to be held. Many decisions were taken which will make the Stockholm Congress noteworthy ; but it is devoutly to be wished that some degree of finality has been reached.

After the Congress there were several excursions. Those to Lapland were well attended, and both taxonomists and phytogeographers there spent a most profitable time.

There was only one shadow—the fear that international relations might again break the ordered sequence of botanical congresses.

OBITUARIES

Dr. S. Maulik

SAMARENDRA MAULIK, who died on July 9 at the age of sixty-eight, was born at Tamluk in the Gangetic Delta on December 25, 1881, and was educated at St. Xavier's College, Calcutta. Afterwards he undertook entomological field-work in Assam, studied at the Indian Museum, and joined the staff of the Forest Research Institute, Dehra Dun.

He first came to England in 1911. At Cambridge, where he took his degree, and at the Imperial College of Science and Technology, he read zoology and entomology. At the British Museum (Natural History) he worked on the Chrysomelidæ, a large family of beetles ; and in 1919 he published, in the "Fauna of British India", the first of his three volumes on the Chrysomelidæ of India.

He returned to India in 1919 as professor of zoology in the University of Calcutta, and successfully directed the initial organisation and equipment of the newly founded Department ; but he soon began to find the life uncongenial.

Within a year or two, therefore, he came to the British Museum again, and settled down—for the rest of his life, as it proved—to work on the Chrysomelidæ, acquiring a world-wide reputation as an authority on this family of some 25,000 species. He demonstrated the value of larval characters as an aid in unravelling true affinities, and discovered in the Halticinæ a femoral structure affording for the first time a clear diagnostic character for their separation from the Galerucinæ. Volumes issued in 1926 and 1936 completed his work on the Chrysomelidæ of India. In appreciation of another of his studies of faunas, he received a Royal Medal from the King of the Belgians. Altogether he published nearly a hundred scientific writings, most of them relating to the Chrysomelidæ, but others including, for example, the account of his recognition (with Stanley Hirst) of the most ancient fossil insect known, preserved in the Devonian Rhynie Chert. He made a number of short contributions to the columns of *Nature*.

During later life he collected from scattered sources about a hundred thousand records of the food-plants of chrysomelid species, and made a tabular summary classifying the records according to the plant families and chrysomelid sub-families simultaneously concerned. He found that the data fall into a definite pattern, from which it is possible to make predictions. It is hoped that the main outlines of this work, the full details of which are preserved at the British Museum (Natural History), will be published posthumously.

At the Museum, Dr. Maulik became a familiar figure. His portrait by Prof. Malcolm Osborne was exhibited at the Royal Academy. From 1934 the Museum recognized him as an unofficial scientific worker or associate. It is specially noteworthy that he built up for the Museum a considerable spirit collection of chrysomelid larvæ.

He had long been a fellow of the Zoological and Royal Entomological Societies and a member of the Société entomologique de France and of the Société linnéenne de Lyon. His D.Sc. was granted by the University of London in 1946.

Maulik was deeply interested not only in scientific subjects, but also in the whole field of human knowledge and endeavour. He was very widely read, and extremely fond of conversation and discussion. He attempted to adopt a scientific attitude in his approach to all problems. His views were liberal, and he was an atheist. In the *Bangalore Mail* and elsewhere he published about forty non-scientific articles on varied subjects. Though he retained a special interest in India, he knew in some respects more than many Englishmen about life in England. His conversation was often of great interest ; but his manner tended to be didactic, superficially vehement, and lacking in consideration for his listener. He was essentially kindly, however, and found it easy to make friends with most people, his circle of acquaintance being very wide and not limited by class distinctions. He took a real interest in the welfare of other people, and his genuine sympathy made it easy for them to confide their troubles. His advice helped many in their careers ; but he was less sure

of himself in his own affairs. Had it not been for the care and support afforded him during thirty-three years by his wife, he could scarcely have accomplished so much work on the Chrysomelidæ.

Poor health during the past two years had necessitated spells in hospital; but in recent months, and until his sudden death from heart-disease, he was working as usual, still full of zest and looking to the future.

LESLIE BAIRSTOW

Mr. D. W. Amos, M.B.E.

THERE are a number of instances of laymen who have quite unconsciously aided the progress of medical science, but extremely few who have, by the pursuit of parasitological studies, added to existing knowledge. Among this company must rank the name of D. W. Amos, a business man who single-handed undertook medical research of a high standard. He lived and worked in Suva, Fiji, for twenty-two years as manager of the Pacific Insurance Co. until 1941, when he retired at the age of sixty-four, and he died there on July 20, 1949, aged seventy-two.

As his contribution to the Allied effort during the Second World War, Amos volunteered to supervise the anti-mosquito work at Nandi Airport (the main airfield of Fiji). This service was designed to prevent the importation of anopheles mosquitoes from the Solomon Islands by American bombers returning thence to their base in Fiji, and thus to guard these healthy islands against the introduction of malaria. During the course of his duties he studied entomology, paying special attention to the filaria-carrying mosquito of these islands—*Aëdes scutellaris pseudoscutellaris*—based upon my original work in 1910–11. In a short space of time he produced a training manual on the mosquitoes of Fiji, written in Fijian, as well as in English, designed for the instruction of Fijians and Europeans employed in the anti-mosquito service. During the course of this work he discovered a species new to the Fijian list and also new to science, *Aëdes (levua) geokusea* Amos, 1944. In 1943, coming into contact with an American medical officer, J. I. Knott, whose work on filariasis is well known, Amos became familiar with Knott's method of abstracting blood from the veins for the diagnosis of filariasis. Thus armed, he embarked upon a thorough survey of the islands and, together with his teams, was responsible for some 63,000 blood examinations, so that statistics compiled from these sources are invaluable.

While working on this survey, Amos came to realize that the vital part of the life-cycle of *Aëdes scutellaris* is the period of inactivity of this insect immediately after a meal on human blood, when it rests upon bushes or upon grass in the vicinity of native huts. His idea was to interrupt the cycle at this point by clearing and maintaining an open space around all the *buris* (huts) in Fijian villages, and, in addition, to keep down breeding by destroying tins, coconut shells and other water-holding receptacles, combined with the filling of tree holes and other breeding-places of this mosquito.

By training Fijians of the anti-mosquito service in these methods and by educating Fijian villagers in these precepts, he was eminently successful; so that, for the first time in its history, filariasis as a menace to the community has begun to recede in Fiji. At his death Amos was mourned as the 'Father of the Fijian people'.

PHILIP MANSON-BAHR

Prof. L. Breitfuss

WHILE on leave at Bad Pyrmont, the Nestor of polar research, Prof. Leonid Breitfuss, ex-councillor of State of the former Russian Empire, died on July 20, aged eighty-five. During his career of fifty years as a polar research worker, Prof. Breitfuss made a name for himself by his co-operation in the ten-year long Murmansk expedition undertaken by the Russian Empire in the nineties of the past century, and, in addition to that, by preparing and advising a great number of German and non-German polar expeditions. Among others were the expeditions in support of Nobile and Amundsen. He finally consolidated his name in polar research by the very important part he played in the foundation of the International Society for the Exploration of the Arctic by Aircraft, called for short 'Aero-Arctic', of which Fridtjof Nansen, the famous Norwegian oceanographer, polar research worker and philanthropist, was the president. Though this Society existed only for a short time, it nevertheless gained a lasting importance from the well-known polar expedition with the German airship *Graf Zeppelin* in 1931.

Prof. Breitfuss, initially a biologist, remained faithful to his first love (his special field was research into sponges) and yet succeeded in consolidating his fame as a historian of polar research far beyond the boundaries of Germany. It was but a short time before his death that, working in Hamburg at the German Hydrographic Institute (of which he had been a member since 1946), he completed his last great work, the "Polar Review". This work will be published by instalments in the "Geographisches Jahrbuch". With its reference list of several thousand titles, and its contributions of recent date, the review will be a comprehensive compilation of sources of value to all engaged in polar research. Its usefulness will extend also to geographers, to geophysicists and to scientific workers in marine economics, for example, whaling.

Many honours both from at home and abroad were recently conferred on Prof. Breitfuss in the house of the German Hydrographic Institute where he had taken up residence, when, some six months ago, he celebrated his eighty-fifth birthday in surprisingly good health and vigour. He was descended from a great Russo-German family whose ancestors were expelled from Salzburg by Bishop Firmian at the time of the confessional wars, but had, by the generosity of the electors and kings of Brandenburg, been allowed to settle in East Prussia. Later on, the family had moved thence to Russia.

It is much to be regretted that Prof. Breitfuss did not survive to complete from the rich store of his knowledge the "Standard Work of Polar Research" as he called it, for to do so had been his most ardent desire for many years. With his death we have lost one of the few surviving representatives of the 'heroic era' of polar research.

Dr. Brysson Cunningham

THE death occurred, on July 31, of Dr. Brysson Cunningham, an authority on dock and harbour engineering. He had contributed several descriptive articles to *Nature* on water-power developments in various parts of the world, all of them based on personal observations during his travels.

Dr. Cunningham was born in 1868 in Liverpool, and studied civil engineering at the University College

there (now the University of Liverpool), while serving as an articled pupil of a local firm of engineers. He obtained the degree of bachelor of engineering from the Royal University of Ireland in 1895, and that of D.Sc. from Queen's University, Belfast, in 1915. In 1890 he had joined the Mersey Docks and Harbour Board, for which he prepared in 1902 an extensive scheme for new construction involving a cost of some four and a half million pounds. In 1906 he left Liverpool on appointment as resident engineer on new work for the London and India Docks Company, and became a member of the headquarters staff and personal assistant to the chief engineer of the Port of London Authority when that body was formed. In 1921 he went into private practice; during 1921–36 he was also lecturer on waterways, harbours and docks at University College, London. During this period he frequently attended meetings of the British Association, becoming a member of the General Committee, and was also very active on the Association's Research Committee on Inland Water Survey, a report of which led to the formation of the Inland Water Survey Committee, under the Ministry of Health, which has recently been reconstituted (see *Nature*, February 18, 1950, p. 263).

Although he retired some ten years ago and went to live at Eastbourne, he retained his interest in his own field; he had edited the *Dock and Harbour Authority* during 1920–26, and he returned to that task in 1937 and guided the journal through the difficult war years.

Dr. Cunningham's writings were marked by a preciseness characteristic of the man himself; small in build, meticulous in all things, he had enjoyed a full life of professional activity.

NEWS and VIEWS

Director of the Science Museum: Dr. F. Sherwood Taylor

Dr. F. Sherwood Taylor, curator of the Museum of the History of Science at Oxford since 1940, has been appointed director of the Science Museum, London, as from October 1, following the death of Dr. Herman Shaw in May of this year. Dr. Taylor was educated at Sherborne School, at Lincoln College, Oxford, and at University College, London. He was an assistant lecturer in chemistry in Queen Mary College, University of London, during 1933–38. His work in the history of science is well known. He is one of the founders and a member of council of the Society for the Study of Alchemy and Early Chemistry, and honorary editor of the Society's journal, *Ambix*. He took an active part in the foundation in 1946 of the British Society for the History of Science and has served on the Council of the Society and in the office of vice-president. He is a consulting editor of *Chymia*, the annual volume of studies in the history of chemistry published by the University of Pennsylvania. Dr. Taylor has published numerous books and papers, both on chemistry and on the history of science. Among these are his "Galileo and the Freedom of Thought", "A Short History of Science", "Science, Past and Present" and "The Century of Science, 1840–1940", and some interesting studies on Greek and later alchemy.

Endeavour Prizes at the British Association

At the conclusion of his presidential address to the British Association at Birmingham on August 30, Sir Harold Hartley announced the names of the prize-winners in the scientific essay competition which has been sponsored by *Endeavour*, a quarterly review of science published by Imperial Chemical Industries, Ltd. The competition was for young scientific workers only, with the object of both stimulating their interest in the work of the British Association and encouraging the writing of good English. The response was considerably greater than was anticipated. 117 essays were submitted. The prize-winners are as follows: *First Prize of Fifty Guineas* to W. J. T. Dunstan (twenty-four years of age) for an essay on "Phenomena at Low Temperatures". He was educated at Stratford Grammar School, London, and at Wadham College, Oxford. In 1946 he became assistant in physics at University College, Dundee, and last year was appointed lecturer in physics at the Northern Polytechnic, London. *Second Prize of Twenty-five Guineas* to S. J. Adelstein (twenty-two) for an essay on "The Biological Significance of Trace Elements". He is an American citizen, and a graduate of the Massachusetts Institute of Technology. *Third Prize of Ten Guineas* is awarded to F. J. C. Rossotti (twenty-three) for an essay on "Radioactive Tracers". He was educated at Christ's Hospital and Merton College, Oxford. He served in Palestine in the R.A.F. until his demobilization in July 1948, and in October 1948 commenced at Merton College, where he is now in his second year. In addition, a special prize of five guineas has been awarded to R. D. Cohen (seventeen), of Clifton College, who sent in an entry of unusual merit for so young a competitor.

Association of British Science Writers

The annual lunch of the Association of British Science Writers was held on September 1 in the University of Birmingham during the recent British Association meeting. Mr. Ritchie Calder (chairman) and Mrs. Calder and Dr. James Lawrie (hon. sec.) and Mrs. Lawrie received the guests, who included Sir Harold Hartley (president of the British Association), Sir Richard Gregory (founder-president of the Association of British Science Writers), Sir John Russell and Sir Henry Tizard. In a short address, Mr. Ritchie Calder pointed out the necessity for such a body as the Association of Science Writers to ensure that properly trained and competent writers are available to report and interpret the findings of scientific workers. In reply, Sir Harold Hartley stressed the great co-operation the British Association has always received from the Press, and the part science writers can and do play in keeping news of science in the foreground.

International Committee for Bird Preservation

The annual report for 1949 of the British Section of the International Committee for Bird Preservation describes the duck adoption scheme which was

launched by the Wildfowl Inquiry Committee at the end of 1948. Under the scheme, on payment of 5*s.* the subscriber is allotted a duck and given particulars of its species, the number of its ring, and date and place of ringing, and later sent any news of it that is received. In addition, for the next two years after paying the subscription, a summarized annual report of all interesting recoveries is forwarded. When the scheme was announced through the Press the result was overwhelming, hundreds of applications for ducks being received every day. As a result the stock of ducks available for adoption ran out and a waiting list of would-be adopters was formed. About 1,700 ducks have already been adopted by more than 1,000 owners. The report also describes the work of the permanent commission on migratory game birds, the international conference of mountain sportsmen and the international union for the protection of Nature. During the year two new member nations, Greece and Spain, joined the committee, bringing the present membership up to thirty-six countries. Copies of the report may be obtained from Miss P. Barclay-Smith, c/o Natural History Museum, Cromwell Road, London, S.W.7, price 2*s.*

Annual Report of the Textile Institute

THE annual report for 1949 of the Textile Institute, 16 St. Mary's Parsonage, Manchester 3, was presented at the recent annual meeting of the Institute, held at Leicester. Increased expenditure due to the rapid expansion of the Institute's work was partly met by increased membership subscriptions; but expenditure for the year again exceeded income, by £5,206. The total annual expenditure of the Institute is about £20,000, which is a minute fraction of one per cent of the amount spent by the textile industry, and it is suggested in the report that the income from industry might very well be considerably increased. A total of 777 new members were elected during the year, bringing the total membership on December 31, 1949, to 4,825. The inauguration of a South Wales and Monmouthshire Section of the Institute brought the number of sections and branches to fourteen. The Institute's *Journal* was issued during the year in two sections, separately bound, and its circulation rose to approximately 5,500 copies. Other publications by the Institute include "Fibre Science", "Jute", a further reprint of "Identification of Textile Materials" and the second issue of the Year Book. Entries in 1949 for both higher and ordinary certificates in textiles were the highest recorded, there being 205 candidates for the ordinary certificate and 93 for the higher, compared with 131 and 85 respectively in 1948. The successes gained in 1949 brought the number of ordinary national certificates awarded since the inception of the scheme in 1935 to 1,169, and of higher national certificates, 599. The increasing desire of students to attain the status of associateship of the Institute was shown by the growing number of entrants for the Institute's annual examination in general textile technology, for which there were 150 entrants, compared with the highest previous total of 114 in 1948. Applicants for associateship in 1949 numbered 218, of whom 75 were elected associates. Of 19 applications for fellowship, 17 were granted. The number of fellows in membership at the end of 1949 was 309, and of associates, 781. The first award of the new £1,000 scholarship was made to G. R. Haines, and the seventh award of the £750 scholarship (now to be offered annually) went to J. C. Hilton.

Noise and Sound Transmission

IN the summer of 1948 the Acoustics Group of the Physical Society held a symposium on noise and sound transmission, at which representatives from many countries attended. The proceedings of this symposium have recently been published in book form (pp. 200; London: Physical Society, 1949; 17*s.* 6*d.*; to fellows and members of the Acoustics Group, 10*s.* 6*d.*), and the forty-one contributions, though they vary considerably in size from a brief abstract in some cases to a lengthy detailed report in others, show that fundamentally the same problems are being tackled in different countries. The first half of the report deals with sound transmission. Leo Beranek, of the Massachusetts Institute of Technology, who was the official representative of the Acoustical Society of America, presents a paper on sound transmission through partitions. He describes experiments that he and others are conducting and which are aimed at, first, the development of a new method of measurement of the transmission and absorption of sound by panels, and, second, the verification that the attenuation of sound by multiple structures can be accurately calculated from the density, flow resistance and dimensions of the components. There are several important contributions from members of the National Physical Laboratory and of the Building Research Station. Much practical information has been collected with regard to sound insulation of party walls between dwelling houses. The articles on domestic noise, noise in schools, ships and aboard aircraft are very interesting, and many readers will be at once attracted to the paper on sound insulation between flats in the hope of finding a solution of this most urgent problem. The latter half of the report, dealing with noise measurement, commences with a review of the problem by R. S. Dadson, of the National Physical Laboratory, and in several of the subsequent papers noise-meters and instruments for the measurement of loudness, vibration, electrical interference, complex sounds and machinery noise are discussed. The report concludes with a written communication from the United States National Bureau of Standards on the transmission of reverberant sound through single walls.

Low-Alloy Steel Standards for Spectrographic and Photometric Analysis

EIGHT standards, representative of the low-alloy steel range, are now available for routine and research spectrographic analysis. The increased use of spectrographic analysis during and since the Second World War led the British Iron and Steel Research Association's Methods of Analysis Committee, through its subcommittee on spectrographic analysis, to put high on its programme the provision of standards. Work on the subject began late in 1946, and recommended compositions for two series, low-alloy steel and residuals, were drawn up. The manufacture, physical preparation and preliminary analyses of the low-alloy series has been undertaken under the supervision of the Bureau of Analysed Samples, Ltd. The eight standards are available in the form of half-inch diameter rod and are intended to cover a range of up to 5 per cent of the more usual alloying elements in steel, the iron content of each standard being approximately 94½ per cent. Analytical standardization has been carried out on behalf of the Methods of Analysis Committee by twelve co-operating

chemists in industrial, government and research laboratories, including the Bureau. The steels are also available in the form of fine turnings as standards for photometric methods of analysis, as an alternative to standardization by means of pure metals. The turnings for photometric standardization are supplied in a series of eight bottles, each containing either 100, 50 or 25 gm. in each. Both the rods and the turnings are obtainable direct from the Bureau of Analysed Samples, Ltd., 234 Marton Road, Middlesbrough, or through any well-known laboratory furnisher.

American Committee for the Study of Alcoholism

THE Division of Medical Sciences of the United States National Research Council has recently set up a Committee on the Problems of Alcohol to initiate and support scientific research concerned with the varied actions of alcohol as a component of the diet or as a beverage and with the special social, psychological and medical problems created by its excessive consumption. The Committee consists of fourteen persons and includes representatives from industry as well as scientific fields bearing on research into alcoholism; the chairman of the Committee is Dr. Chauncey D. Leake, vice-president of the University of Texas Medical Branch, and Dr. Joseph Hirsh, of New York University, is the executive secretary. Information on the work of the Committee, including methods of submitting proposals for grants in support of research on problems of alcohol, may be obtained from the Secretary, Committee on Problems of Alcohol, Division of Medical Sciences, National Research Council, 2101 Constitution Avenue N.W., Washington 25, D.C.

Colonial Service: Recent Appointments

THE following appointments in the Colonial Service have recently been announced: H. K. Ashby (agricultural officer, Federation of Malaya), senior agricultural officer, Federation of Malaya; G. T. Barnes (pathologist, Fiji), pathologist, Nigeria; D. A. R. Campbell (agricultural officer, grade 2, Jamaica), senior agricultural officer, Jamaica; H. G. Michaelides (forest assistant, Cyprus), assistant conservator of forests, Cyprus; P. E. Nesbitt (laboratory superintendent, Nigeria), senior laboratory superintendent, West African Institute, Trypanosomiasis Research, Nigeria; W. G. Stuart (agricultural officer, grade 1, Jamaica), senior agricultural officer, Jamaica; J. R. Low, agricultural officer, Uganda; K. McKerron, agricultural officer, Aden; J. K. B. Booth, geologist, Tanganyika; J. M. Brown, geophysicist, Geological Survey Service, Uganda; J. Dawson, S. MacDonald and A. Renwick, geologists, Federation of Malaya; A. Hatton and J. V. Hepworth, geologists, Uganda; P. N. Banks, W. D. C. Parkes and J. D. J. Ross, veterinary officers, Tanganyika; H. E. D. R. Williams, veterinary officer, Trinidad; J. A. G. Glenn, game ranger, Tanganyika.

Announcements

DURING the meeting of the British Association at Birmingham, the honorary degree of D.Sc. was conferred on Sir Harold Hartley, president of the Association, at a congregation held in the Great Hall of the University on September 2.

MR. T. C. DENSTON has been appointed secretary of the British Pharmacopœia Commission in succession to Dr. C. H. Hampshire, who will retire on October 3.

OWING to the growth of the garden work and investigations at the John Innes Horticultural Institution at Bayfordbury, it has been found necessary to separate the research and administrative sides of the Garden Department. Mr. W. J. C. Lawrence who, as curator, has been in charge of all the cultivations and research on cultivations since 1932, has been appointed to the purely research post of head of the Garden Research Department, where he will be free to continue his investigations on all aspects of indoor and outdoor cultivation. Mr. J. Newell, who has been assistant curator since 1936, becomes curator in charge of the garden administration at Bayfordbury.

THE annual conference of the Society of Leather Trades' Chemists will be held in the University of Leeds during September 22–23. On the afternoon of September 22 the fourth Procter Memorial Lecture, for which tickets are available to non-members, will be given by Prof. E. K. Rideal, his subject being "Membrane Permeability". Further details of the conference can be obtained on application to the editorial office of the Society at Craigieburn, Duppas Hill Road, Waddon, Croydon, Surrey.

THE Industrial Applications Section of the Royal Statistical Society is organising a conference, to be held in the University of Sheffield during September 29–October 1, on "Scientific Method in Industrial Production", when technicians and managements of manufacturing concerns will be able to meet statisticians interested in industrial problems. The papers on the first day have been particularly designed for non-statistical audiences. Applications for attendance at the conference (fee 1 guinea) should be sent to the Assistant Secretary, Royal Statistical Society, 4 Portugal Street, London, W.C.2.

A SYMPOSIUM on "High-Temperature Steels and Alloys for Gas Turbines" has been arranged by the Iron and Steel Institute and will be held under the chairmanship of Mr. J. R. Menzies-Wilson, president of the Iron and Steel Institute, in the lecture theatre of the Institution of Civil Engineers, Great George Street, London, S.W.1, during October 18–19. The provisional list of papers has been classified into the following sections: introduction, user aspects, supplier aspects, performance aspects (scaling and hot-fatigue), special casting techniques, welding aspects, special blade materials, and research and future needs. Before the symposium, the fifth Hatfield Memorial Lecture will be given by Sir Frank Whittle in the lecture theatre of the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2, at 8.30 p.m. on October 17. Tickets for the symposium and Hatfield Lecture are available to non-members of the Institute. Further particulars can be obtained from the Secretary, Iron and Steel Institute, 4 Grosvenor Gardens, London, S.W.1.

ERRATUM. In the communication by K. O. Müller on "Hypersensitivity and Tumour Development in Potato Tubers in Response to Infections with *Phytophthora infestans*" in *Nature* of August 5, p. 231, paragraph 1, last line, for "hypersensitive" read "hyposensitive".

CIVIL ENGINEERING PROBLEMS IN COLONIAL TERRITORIES

THE second Conference on Civil Engineering Problems in the Colonies, organised by the Institution of Civil Engineers, took place in London during the week July 3–7. Among those present were engineers from most of the British Colonies as well as from the Sudan and French Morocco, the attendance being a 30 per cent increase on that of the first Conference held in 1948.

One of the technical sessions was devoted to a series of short papers on "Engineering Research and the Colonial Engineer", in which the directors of the establishments of the Department of Scientific and Industrial Research more directly connected with engineering reviewed those aspects of their work of particular Colonial interest. Dr. W. H. Glanville, director of the Road Research Laboratory, compared the different factors affecting the design of roads and the selection of road-making materials in the United Kingdom and the Colonies. He instanced the differences in climate and soils, stressing in particular the need for a better classification of lateritic soils, and he discussed the differences in traffic intensities and the means and methods of construction. As yet no permanent solution to the corrugation of earth has been found. He welcomed the setting up in a number of Colonies of laboratories to examine and control road-making materials, and hoped that the recent appointment of a Colonial liaison officer at the Road Research Laboratory would assist in the circulation of information on Colonial road problems.

Dr. F. Y. Henderson, director of the Forest Products Research Laboratory, said that there is an increasing interest in Colonial timbers, and a building in which tropical conditions could be simulated is nearing completion. The Laboratory is now providing a six months course for Colonial forestry officers who are to specialize in timber utilization, and its short courses for public works department engineers have proved very successful.

Sir Claude Inglis, director of the Hydraulics Research Organisation, outlined the work this body would be undertaking as soon as its laboratory is opened.

Dr. F. M. Lea, director of the Building Research Station, referring to some of the problems in which the work of the Station could help the Colonial engineer, discussed the use of stabilized earth for walling and the uses which could be made of local materials, such as lime, gypsum and pozzolanas in place of Portland cement. He also mentioned the care required in using new types of aggregate in concrete which might react with alkalis in the cement. Of the Station's work on structures, he discussed the use of alternative cements in concrete to increase its resistance to deterioration, and the work on steel frameworks and the design of bridge-deck slabs in relation to steel economy. The work of the soil mechanics division is of particular interest, especially in relation to the design of foundations on expansive soils which are subject to seasonal movement, and to the problems of soil erosion and special types of soil which occur in the Colonies.

Dr. B. A. Southgate, director of the Water Pollution Research Laboratory, pointed out that the work of that Laboratory includes the development of methods of treatment of polluted water and of sewage and industrial waste liquors, as well as the investigation of the effects of pollution on natural waters. Many requests for advice and assistance on these problems are received each year, some of them from the Colonies, where correspondents—usually public health officers—have been appointed by the Colonial Office. Some work has been carried out by the Laboratory's staff on the treatment in East Africa of waste waters from the processing of coffee and the decortication of sisal.

In a paper on "Investigations and Construction of Tropical Water Supplies", Mr. D. S. Bulbin described work carried out during his twenty-one years in the Public Works Department, Nigeria. One of the most troublesome problems with which the engineer in the Colonies is confronted is the inadequacy of the data available on which to design public water supplies. In Nigeria the only topographical survey sheets—to a scale of 1 : 125,000 with contours at 50 or 100 ft. vertical intervals—suitable for determining water catchment and reservoir areas cover about one-sixth of the country. A start has, however, been made with aerial surveys which will greatly assist this work. It is difficult, because of the range of conditions in Nigeria, to establish percentage-variations from the average rainfall at different stations. For example, in 1946 a new minimum was recorded at the head works of the Lagos water-supply which was about 50 per cent of the 35-year average. There is also little information on rainfall-intensities. The only available self-recording rain-gauges were designed for United Kingdom intensities, and, because they magnify the fall on the chart, are not suitable for the measurement of tropical rainfall-intensities. He had therefore designed a 5-in. gauge which records the rainfall on a continuous direct-reading weekly chart, 1 in. of rainfall being represented by $\frac{1}{4}$ in. on the chart. The maximum capacity of the container is 24 in., which is ample for most places in Nigeria. The device has been built up locally, the clock drum, float, pen and charts being imported.

The only reliable method of arriving at run-off figures from a catchment is by direct stream-flow recording, and this is being done so far as possible in Nigeria, though rainfall figures must necessarily give the first indication of the possibilities of a catchment area. One of the problems is that rainstorms are very localized. Another is that the widths of streams and rivers may not bear any relationship to the area draining into them. Considerable variation in run-off figures has been observed; but, for actual design, an overall figure of 22 per cent of the total rainfall is being adopted. A further aspect of run-off, experienced in the southern area during the past few years, is the drying up of large rivers with catchment areas running into many hundreds of square miles. The area has normally an ample rainfall and the cause of this drying up is difficult to understand, one probable cause being the shifting cultivation methods of the African farmer, which encourage a quick run-off during the rainy season with little rain penetrating into the ground. The lack of reliable information about the run-off also makes the calculation of flood-flows difficult.

A further problem is the estimation of water consumption for any scheme. Reliable population figures are rarely available, but, as taxes are usually levied on the adult male population, a simple though

approximate method is to multiply this number by a factor, normally 3·6. The floating population, always considerable in market towns, is another unknown factor, and in Northern Nigeria large numbers of animals have also to be watered. For new schemes, a consumption of 10 gallons per head per day has been adopted, and in addition provision is made for hospitals, schools and for the railway.

In the north, the sand beds of large rivers which cease to flow for some five months of the year are often the only possible source of supply, and an improved type of well-intake in sand has been designed. No large dams have yet been built in Nigeria, but earth embankments with an impervious core and straight concrete overflow-weirs have been used. Since about 80 per cent of the population is rural, the provision of rural water supplies is very important, and a considerable amount of work has been carried out in this field.

Two papers were devoted to the problems of Colonial railways and ports. The first, presented by J. R. Farquharson, discussed the "Railway and Port Problems in East Africa". There has been a steady growth of traffic on the railways and through the ports since development began in East Africa at the beginning of the century. The rate of increase of traffic has been particularly rapid during and since the Second World War, when it was difficult to obtain staff and supplies. Increased demands on the transport services have necessitated works and improvements of all types. These include the provision of housing for railway staff, some major reconstructions of station workshop buildings and the rearrangement and strengthening of the track between Nairobi and Nakuru in Kenya. Other sections are shortly to be strengthened. At the same time it has been necessary to construct new lines to serve specific projects, of which the two principal are the 130-mile line to the Mpanda line in the western province of Tanganyika and the 160-mile railway in the southern province of Tanganyika constructed solely to meet the requirements of the Overseas Food Corporation.

Various other projects for the extension of the East African railway system have been considered at intervals during the past quarter of a century, the four main projects being, first, a connexion between the Tanga and Central lines in Tanganyika; secondly, a line southwards from the Tanganyika Central line, ultimately linked with the Rhodesian system; thirdly, a line to serve the coal-fields of southern Tanganyika, connecting either with the projected line between Tanganyika and the Rhodesias, or with the new line in the southern province; and fourthly, a line from Kampala to serve western Uganda and (ultimately) to join the transport system of the Belgian Congo. Mr. Farquharson commented on each of these projects. He thought the Tanga and Central lines in Tanganyika are likely to be connected during the next ten years or so, and that the time might soon be ripe to start construction on that part of the proposed link with Rhodesia serving the Njombe area of Tanganyika, although differences in gauge between the two systems will complicate the completion of this link. The examination of the coal-fields in the Ruhuhu valley, north-east of Lake Nyasa, is not yet completed, and until the probable markets for the coal and its derivatives can be more clearly determined, it is difficult to advise on railway development in this area. A preliminary survey of a line from Kampala to the Uganda–Congo border was completed in 1930, but it was not built then because of the onset of the economic depression. However, interest in the copper/cobalt occurrence at Kilembe, in the Ruwenzori mountains, has recently been revived.

The second paper at this session was devoted to harbours and wharfs in the Colonies, and was presented by R. D. Gwyther. In a great number of ports in the Colonies the handling of goods between ships and shore has been carried out by lighterage; but the greatly increased trade developed by the Dominions and Colonies, from which increased revenue has been derived, has, in many cases, enabled deep-water berths to be provided. Wharfs have been, or are about to be, constructed in several ports, and their design is therefore of considerable interest at the present time. After pointing out the advantages of adopting the solid type of structure, Mr. Gwyther dealt with the various matters such as width of apron, type of sheds, and the arrangement of rail tracks, cranes and fittings which are required to facilitate the handling, storage and clearing of cargo. Reference was also made to the provision of oil-berths and the bulk loading of certain commodities. He then described some of the new harbour works at present being carried out in British Colonies; such as wharfage extensions at Lagos, Nigeria and Takoradi, Gold Coast, and new harbour works at Freetown, Sierra Leone, and Mtwara, Tanganyika. Finally, as a comparison with the modern blockwork quay wall, an earlier type of quay was described, constructed about sixty years ago at Castries, in the West Indies, which has stood the test of time, and proved adequate for the purpose for which it was designed.

Other papers were devoted to the construction of roads and airports. A. J. Mitchell spoke on "Survey and Design of Low Cost Roads for Colonial Conditions, with special reference to the Principles of Soil Mechanics". Recent advances in the science of soil mechanics have had far-reaching effects on highway engineering, particularly the branch dealing with low-cost roads which, for economic reasons, have to be employed extensively in the Colonies. By the application of the principles of soil mechanics to this type, in which the soil, gravel or other material in the road bed itself forms the greatest part of its composition, it is possible to produce a road which will maintain an adequate degree of stability under a considerable range of traffic and weather conditions, at a cost which is often considerably lower than that of some traditional construction. Mr. Mitchell described a scheme of work covering the operations of reconnaissance, detailed survey and design of the road, based on recent experience in Tanganyika. He discussed the various methods for the improvement of the foundation and of the base-course, by soil stabilization, compaction, etc., and the current methods of designing the thickness of flexible base-courses. An analytical method of design has been worked out, largely derived from the work of previous investigators, which has the advantage of being based on the accepted theories of soil mechanics and related to standard soil tests. A simpler empirical method was also suggested for use in conditions which do not justify the former method. The paper concluded with a discussion of the problem of subsequent maintenance of the road surface so far as this affects design, and recommendations were made for the design of bituminous and non-bituminous surfaces.

The second paper on road and airport construction, by W. R. Scott, was on "The Design and Construction of the Livingstone Airport, Northern Rhodesia".

The increase in air traffic throughout the Colonies since the end of the Second World War has necessitated the construction of many new airports. In some Colonies these have had to be of very heavy construction in order to be capable of handling the large airliners operating on the main trunk routes. Internal air-traffic, while it may need the provision of only short and comparatively narrow runways and light pavements, depending upon the frequency of the services, often calls for elaborate ancillary equipment and accommodation to house it. Such facilities could be, and usually have been, provided by improving pre-war airfields. However, with the advent of heavy transcontinental airliners operating on the main trunk routes, it was found that there were few existing runways which could, economically, be extended and strengthened to the necessary standards; furthermore, even if expansion were economical, the requirements for clear flightways and safety zones could not be fulfilled; that factor alone dictated the need for entirely new sites. The Livingstone project called for runways, buildings, and other facilities for handling both increased feeder-traffic and large transcontinental traffic. Mr. Scott, who, as resident engineer under instructions from the Director of Public Works of Northern Rhodesia, prepared the scheme and supervised the construction, described the work undertaken.

During the conference, visits were arranged to various works and research stations. The opportunity was also taken of the visit to Britain of Prof. Gordan M. Fair, of Harvard University, who gave a talk on the development of public health engineering in the United States.

OIL SHALE AND CANNEL COAL

THE second Conference on Oil Shale and Cannel Coal was held under the auspices of the Institute of Petroleum at Glasgow during July 3–7, when nearly fifty papers, covering a wide range of subjects, were presented and discussed. The papers were divided into two sections: (*A*) geology, mineralogy and mining; and (*B*) retorting, refining and use of by-products. No attempt has been made in the present review to make a comprehensive statement covering all—or nearly all—the papers, nor are the following remarks divided in accordance with the above classification. It has seemed better to concentrate on certain outstanding features of the Conference, as giving an outline of some of the subjects which will be treated in detail in the complete report to be issued later by the Institute of Petroleum.

It is noteworthy that interest in the development of the oil shales as a source of liquid fuels is not confined to those countries whose resources of well-oil are negligible or entirely absent; intensive work has also been carried out by the Bureau of Mines in the United States with the view of working out a basis for the re-establishment of the oil shale industry in that country. It may not be generally realized that, following the pioneering work of Dr. James Young in Scotland during the 1850's, a number of firms in the United States produced oil by the retorting of oil shales; but the inception of the petroleum industry, which arose when, in 1859, Colonel Drake sank the first well for the specific purpose of producing oil, resulted in such a reduction of costs that the oil shale industry was unable to compete. The increased cost of finding and winning oil from wells has, however, rendered it possible that before many years have elapsed it may be economic, and even necessary, for technologists in the United States to turn their attention to the production of oil from retortable materials.

One of the difficulties which confronts him who would write or speak of oil shales and similar materials is the absence of any comprehensive classification and standard nomenclature. Although at the previous conference, which was held in 1938, a resolution was passed inviting the Institute of Petroleum to take steps to secure a standard nomenclature, the advent of the war in 1939 prevented the implementation of this resolution, and there is still no satisfactory classification or system of nomenclature. R. A. Mott (Sheffield) proposed to divide the canneloid materials into 'coals' (cannels, cannel bogheads, boghead cannels and bogheads or torbanites) and 'shales' according as they yield less or more than 40 per cent ash when incinerated. The 'coals' are subdivided on a basis of yield of volatiles (calculated on the dry mineral-free basis) and specific gravity. G. W. Himus (London) discussed the little that is known of the composition and constitution of the kerogen rocks, pointing out the wide variation in composition and nature both of the organic and mineral components. He directed attention to the fact that what are generally called 'oil shales' may be limestones, true shales, quartzose silts and of intermediate types; therefore the name 'shale' applied simply on a basis of yield of ash may be misleading.

C. H. Prien (Denver, Colorado) summarized the history and what is known of the occurrence and geological origin of oil shale and shale oil, and the various methods of retorting which are in use. J. A. Dulhunty (Sydney) gave an account of the occurrence and origin of the Australian torbanite, which is a good example of a deposit of algal origin, almost free from admixture with other materials.

Numerous papers dealt with methods employed in mining oil shale. Room and pillar methods appear to be the most favoured, although J. M. Caldwell, J. Stein and R. Keddie (Scottish Oils, Ltd.) described the application of longwall working at Broxburn. Until the advent of more robust plant than was available prior to 1940, coal-cutters were considered to be unsuitable for use in shale mines owing to the harder and heavier nature of oil shale. E. D. Gardner and E. M. Sipprelle (United States) gave an account of the methods of mining the Mahogany Ledge of the Green River shales at Rifle, Colorado. The bed is 27 ft. thick, and after the rock has been blasted, the broken shale is loaded by a 3-cu. yd. electric shovel into 15-ton diesel trucks for conveyance to the surface. An output of nearly 150 tons per man-shift underground has thus been secured.

The normal procedure in the production of shale oil involves winning the shale, transporting it to the carbonizing plant, carbonizing at approximately 500° C., and condensing the oil. A revolutionary method of recovering shale oil by carbonizing *in situ* was invented by F. Ljungström and was described by G. Salomonsson (Sweden). A comprehensive research was first undertaken, during which the method was treated mathematically, chemically and physically, and, having been found to be feasible, a full-scale plant was erected by the Swedish Shale Oil Co. at Norrtop. The seam of shale is about 55 ft. thick, dips gently to the south, and is covered by a bed of limestone, 20–23 ft. in thickness, which forms

a gas-tight 'roof' preventing leakage of the vapours. The shale is heated by about two thousand electrical elements arranged in a hexagonal pattern, with offtake pipes for the vapours between them. The final temperature is about 400° C., and the pressure generated is sufficiently high to force the vapours up the pipes in the centres of the hexagons through the condensing plant. As the heating of one part of the rock is finished, the heaters and offtake pipes are moved forward, the rate of travel being about 460 ft. a year. The actual time of heating of any one section of the shale field is about five months. The oil is condensed in specially designed forced-draught, air-cooled condensers, and the light vapours are then recovered by scrubbing the gases with crude oil. The gases, which contain 25 per cent sulphuretted hydrogen, are treated in an Alkazid–Claus plant for the recovery of sulphur and are then used as a fuel in a power plant. The calorific value is 955 B.Th.U. (gross), or 870 B.Th.U. (net) per cu. ft. The consumption of power is 6·4 kWh. per litre of oil, and the yields per sq. m. of ground are: oils (containing 50 per cent gasoline boiling to 200° C.), 1,025 litres; liquid propane and butane, 80 kgm.; washed gas, 650 cu. m.; sulphur, 320 kgm.; and ammonia, 8 kgm.

A novel and interesting retort was described by C. Berg (Union Oil Company of California). The plant is designed to reduce the cost of retorting and also to avoid the use of water for condensing the oil. To effect the latter, the retort is fed with raw shale from the bottom, and distillation takes place downwards, the cold incoming shale being used to condense the oil vapours. Heating is carried out by burning the carbon in the spent shale by drawing a current of air downwards through it; transfer of heat is thus effected by convection, and therefore large cross-sectional areas can be effectively heated and large throughputs obtained.

J. Givaudon and P. Dumoutet (France) described tests on the utilization of calcareous shale of Dotterhausen (Würtemberg). Carbonization is carried out in an internally heated, continuous brick retort, the heat necessary being supplied by burning the residual carbon in the shale. The spent shale can be used directly as hydraulic lime. The retort is approximately 8 ft. by 8 ft. in cross-section, 37 ft. high, and has a throughput of 50 tons a day, and it is claimed that, owing to the wide range of possible operating conditions, any quality of shale can be handled. The shale of Dotterhausen is of low grade, yielding 4·35 per cent by weight of oil in a laboratory assay; in the Carburants et Lubrifiants retort, yields of 4 per cent oil have been obtained.

In contrast to the above are the Westwood retorts of Scottish Oils, Ltd., described by G. H. Smith and A. Balloch. These retorts, of which there are 104, arranged in two benches, at Westwood, are a modification of the Woodall–Duckham continuous vertical, with a 14-ft. cast iron section above a 20-ft. section of firebrick. About two-thirds of the heat required is supplied by burning the carbon of the residual shale within the retort, while the balance is supplied by combustion of the stripped gas in flues built around the retorts. The throughput of each retort is approximately 12 tons a day.

R. Labourel (France) described the method of utilizing the 15 per cent of fine shale which is produced at the mines at Autun, and which was previously thrown to waste as being unsuitable for charging into the retorts. This material is now finely pulverized and burned under boilers; and, as the result of a continuous run of twelve months, the problems arising in the combustion of the pulverized shale have practically been solved. It has been established that, if utilized where it is extracted, the pulverized shale from Autun compares favourably with coal for the production of steam.

A number of papers were devoted to the subject of refining (including hydrogenation) of shale oil. The methods employed are based on those of the petroleum industry, certain modifications being necessary to cope with the special characteristics of the raw materials.

Scottish Oils, Ltd., have made a successful incursion into the highly competitive brick industry at their Pumpherston works, and the plant was described by A. Anderson and J. McCallum. The principal material used is spent shale, which must be well weathered to ensure that all the carbon has been burned off and the iron oxidized to the ferric condition. The carefully selected spent shale is first dried, then crushed in a rod-mill, after which it is mixed with the requisite quantity of calcium hydrate (partly dry, and partly as a slurry) in an edge-runner mill. The plastic material from the mixer is then passed through two duplex fourteen-stamp brick presses, each of which produces forty-two bricks per minute. The bricks from the presses are loaded on to bogies which are then run into autoclaves, where they are subjected to steam-curing at 145 lb. per sq. in. and a total temperature of 480° F. When discharged from the autoclaves, the bricks are ready for dispatch. Immediately after curing, the bricks exhibit a white to pink appearance; but all whiteness quickly vanishes, leaving a pleasant, somewhat variegated pink surface. The capacity of the plant, working three shifts, is 80,000 bricks per twenty-four hours; production at the present time is 32,250 bricks, working a single shift on each press. The crushing load averages 31 tons per brick (wet) or 34 tons per brick (dry), and the absorption of water is 12 per cent of the dry weight, although this varies somewhat, depending on the grading of the mixture and the compression in the brick press. The brickmaking project was commenced in 1934, more to provide employment than to reduce the unsightly bings of spent shale which are such noticeable features in the oil shale field; indeed, only 110 tons of spent shale are used daily, while several thousand tons are produced by the crude-oil plants each day.

As a result of joint work by Scottish Oils, Ltd., and the Anglo-Iranian Oil Co., Ltd., synthetic detergents are now being manufactured at the works at Pumpherston; the process was outlined by D. Stewart and E. McNeill. The raw material is a shale oil fraction having a boiling range of approximately 180–330° C. After being washed with dilute sulphuric acid and then with caustic soda to remove nitrogenous bases and tar acids and phenols, the oil is redistilled. The distillate is treated with 96–98 per cent sulphuric acid, whereby the olefins are converted into a mixture of alkyl and di-alkyl sulphates, together with some polymer tar. The latter is separated in centrifugal separators, the tar flowing to a separate plant where sulphuric acid is recovered and the organic portion of the tar prepared for use as fuel. The 'sulphated oil' is neutralized by a solution of sodium carbonate, the mono-alkyl sulphates being converted into sodium salts. The sodium alkyl sulphates immediately emulsify the unreacted oil to a cream-coloured emulsion. The temperature is then

raised to 90° C., and by maintaining these conditions for five to six hours the yield of monoalkyl sulphates is increased by hydrolysis of the di-alkyl sulphates. After the batch has been cooled, the emulsion is broken by the addition of weak *iso*propanol. Two layers form, the upper consisting of unreacted oil and alcohol, the lower of an alcoholic solution of sodium alkyl sulphates with unreacted mineral oil and excess alkali. The upper layer is redistilled for the recovery of alcohol, while the oil is returned to the refinery for processing to diesel oil. The alcoholic detergent layer is freed from mineral oil by washing with suitable solvent spirit, after which it is concentrated and freed from alcohol and solvent spirit (which has replaced the unreacted oil), and finally leaves the evaporators as a syrupy liquid.

The Conference was well attended, and there were lively discussions on some of the papers. It is apparent that there is widespread appreciation of the importance of the oil shales and related materials as potential sources of oil, and much experimental and pioneering work is being carried out on the production and refining of shale oil. There seems, however, to be comparatively little work in progress on the more fundamental aspects of the chemical composition and constitution of the oil shales; therefore there is a lack of balance in the picture as presented by the Conference.

THE VETERINARY PROFESSION IN INDIA

IN his presidential address to the tenth All-India Veterinary Congress held last April in Bombay, Dr. S. Datta, director of the Indian Veterinary Research Institute, Mukteswar, appealed for the creation of an Indian veterinary council, which should be a statutory body set up by Act of Parliament, with power to enforce a high standard of veterinary education in Indian veterinary colleges, to suppress quackery in the veterinary profession and to co-ordinate the work of the various State veterinary departments. Dr. Datta also urged the creation of an all-India veterinary association with affiliated State associations, the function of which would be to look after the interests of Indian veterinarians.

The reasons why India needs a higher standard of veterinary education and a better co-ordination of veterinarians and their work were discussed in the course of Dr. Datta's address. He deplored the lack of interest shown by the State and the public in the welfare and improvement of farm stock, and rightly urged that veterinarians should not merely wait until disease occurs and then try to remove or prevent it. Directing special attention to the importance of Indian cattle, he said that agriculture in India is really dependent upon animal husbandry, because farm animals in India are often the only source of power for agricultural work and they supply, in dry areas, the motive power for land-irrigation; they are the mainstay of transport in agricultural areas and the chief source of manure. Assessing the individual values of transport, manure, hides, milk and milk products, eggs and wool, Dr. Datta estimated that the income derived directly and indirectly from farm stock represents two-thirds of the Indian national income. Apart from the control of the preventable diseases which cause heavy losses, there is urgent need for the establishment of good pastures, the preservation of grasses as hay or silage, the utilization of slaughterhouse waste, and the preparation and distribution of processed livestock foods. But these are only short-term measures; they cannot succeed unless scientific systems of breeding are also established, by means of which the number of animals can be reduced and their productivity increased.

Urging State participation in this policy, Dr. Datta regretted that at present the State spends on veterinary projects and animal husbandry only 0·08 per cent of the total budget grants. He described a programme for the development of disease control and animal husbandry and discussed the lack of properly educated veterinarians. India has only 10 veterinarians per million head of livestock, whereas Great Britain has 95 and Switzerland 248. India, said Dr. Datta, requires developments in veterinary education equal to those which have occurred in Britain and other countries. Although new Indian veterinary colleges have been established and a better scientific education is being given, the men who are giving this education have been drawn from the Mukteswar Institute, and the demand for leaders of this kind is now greater than the supply. The existing plans for the enlargement and reorganisation of the veterinary profession upon which the supply of leaders depends should therefore not be held up any longer, and an Indian veterinary council is required.

Dr. Datta's views will be supported by everyone who is interested in the welfare of India, whether they see the future of this great country from the outside, or have been, until recently, quietly laying the foundations upon which the reorganisation outlined by Dr. Datta could be brought into being. Quite apart from political or economic considerations, this reorganisation and development is urgently required for the sake of the farm animals themselves.

G. LAPAGE

EVOLUTION IN BACTERIA AND THE SIGNIFICANCE OF THE BACTERIAL SPORE

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THE tendency of most groups of living creatures to evolve from a condition in which structure and function, and especially the reproductive and distributive functions, are adapted to an aquatic existence, to a terrestrial form, is clearly discernible in bacteria.

Purely aquatic bacteria are of three main types, of which one is free-swimming and two are sessile. The free-swimming bacteria are more or less spiral in form, much more so than the truly terrestrial bacteria. The sessile bacteria may be stalked (caulobacteria) or filamentous (chlamydobacteria), or, in some cases, both. Thus bacteria may make use of, or resist, the distributive potentialities of the water.

Bacteria of many other types are found in water; but some are unquestionably there by accident, and only the spiral and sessile forms appear to be specifically adapted to an aquatic existence.

Distribution, under aquatic conditions, does not present a serious problem. The spiral forms swim freely and their non-motile, resting stages, where these exist, drift in the currents. The sessile forms usually possess a motile stage, by which distribution is effected. The swarm cells of chlamydobacteria and the flagellated generation of caulobacteria[1] perform this function.

Although there is little direct evidence, I am inclined to the opinion that the spiral water bacteria, with their polar flagella, are the ancestral bacterial form.

Caulobacteria and chlamydobacteria have no terrestrial representatives and may be regarded as highly evolved for life in very dilute nutrient media, such as streams and lakes.

As in the case of plants and animals, many bacterial species which are terrestrial in habit possess features indicative of an aquatic origin. Of these, the tendency towards a spiral morphology[2] and the possession of flagella are obvious examples. In certain terrestrial species the flagella have been developed to such an extent that the organism is capable of active movement upon a surface that is no more than damp. This is characteristic of *Proteus* and of many sporing genera. The flagella of these bacteria are not, so far as is known, different from those of other species, but are exceedingly numerous, and are peritrichous in arrangement. The flagella of aquatic bacteria, by contrast, are usually few in number and confined to the poles of the cell, and such bacteria often swim more actively than those with peritrichous flagella.

Many species, less completely adapted to terrestrial conditions, possess flagella which are apparently of little use to them. For example, bacteria of the *coli*-typhoid group are capable of swimming actively, although this function can be of little service to them. It is, however, noteworthy that when typhoid bacteria are swimming freely, many of their flagella become twisted together into a tail at the end of the cell[3]. This may be a device for greater efficiency, or it may be merely an accident. Whatever the explanation, the inference that peritrichous flagella are imperfect swimming organs is difficult to escape. It is also worthy of note that the polar or sub-polar flagella of *S. typhi* are the first to develop in the germinating microcyst[3]. The theory of recapitulation is not now held to be entirely true, but it is of some interest in such a case. The commonest free-living genera of this group are actually non-motile and depend upon passive distribution, apparently with success.

The problem of adaptation to movement upon dry land has been solved in an entirely different manner by the Myxobacteria, which have discarded flagella entirely, and with them the rigid cell wall of the eubacteria. Myxobacteria crawl upon solid surfaces, or surface films, by muscular activity of the cell wall. They cannot 'swim' when they are immersed in a fluid. They have also achieved a solution of the problem of distribution of the species under terrestrial conditions.

As has already been suggested, the distributive units of aquatic bacteria are motile cells. On dry land, however, this type of motility is inadequate to ensure distribution, and the most successful groups have evolved mechanisms for ensuring carriage of endospores, microcysts, or oidia by the air.

The Myxobacteria produce fruiting bodies, of which the most elaborate are very well designed for this purpose. They range from mere heaps of microcysts to complex structures with a large surface area to catch the air, borne upon long stalks[4]. Each fruiting body contains many microcysts, so that, upon germination on a suitable substrate, an entire vegetative swarm is released. This must ensure, to some extent, that the newly germinated bacteria are not overgrown by those already present.

Two other groups which have developed parallel mechanisms are the Streptomyces and the sporing bacteria. The fungus-like habit of the former needs little comment. Spores are borne upon aerial hyphæ, and combine large numbers with small size to ensure distribution. The sessile, plant-like organism is entirely immobile. The sporing bacilli are less specialized, but almost equally successful, and have produced the rather puzzling endospore. It seems to me that the main function of the spore is aerial distribution. It is probably no more than the eubacterial microcyst[5], considerably reduced in size for the sake of lightness and, therefore, concentrated. It is this concentration of the protein, by the elimination of water, that is responsible for the resistance of the spore to inimical agencies. This can scarcely have developed because of any real advantage which its possession gives to the species. High temperatures and strong concentrations of chemicals are rarely met with in Nature; whereas the resistance of the spore to oxidation and inanition is little, if any, greater than that of the resting stage of other types of bacteria.

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A METHOD OF INTEGRATING THE GIBBS ADSORPTION ISOTHERM

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THE force (π) – area (A) relationship for the adsorbed film of a soluble substance can be obtained from the equilibrium surface pressure (π) – concentration (c) curve by a graphical application of Gibbs's adsorption isotherm. This can be applied in two equivalent forms:

$$n = \frac{c}{kT} \cdot \frac{d\pi}{dc}, \qquad (1)$$

$$n = \frac{1}{kT} \cdot \frac{d\pi}{d\ln c}, \qquad (2)$$

where n is the number of molecules/cm.^{2} $= 1/A$ (assuming that the activity coefficient is unity).

A study has been made of the application of these equations to solutions of normal aliphatic alcohols, and it has been found that (1) is not readily applied in regions of high curvature of the $\pi \sim c$ curve (π greater than 15 dynes/cm.) owing to the large error in the graphical determination of $d\pi/dc$. Use

of (2) indicates a region of constant adsorption which, from surface potential measurements, does not exist. Thus equation (2) tends to smooth out the significant changes in $d\pi/d\ln c$.

In the region $\pi = 0$–10 dynes/cm., where the above equations can be accurately applied, the films are perfectly gaseous and obey an equation of state

$$\pi A = kT.$$

Studies on insoluble monolayers[1] and some adsorbed films[2] show that for π greater than 15 dynes/cm. many films obey a modified form of the above equation, namely:

$$\pi(A - A_0) = xkT,$$

where A_0 is the co-area of the molecule (generally less than its cross-sectional area) and x is a measure of the lateral adhesion of the molecules in the film, being unity when there is no adhesion and decreasing as the adhesion increases. Substituting this equation of state into equation (2):

$$\frac{d\ln c}{d\pi} = \frac{A_0}{kT} + \frac{x}{\pi}.$$

Integrating, assuming A_0 and x constant,

$$\ln c = \frac{A_0}{kT} \cdot \pi + x \ln \pi + D, \qquad (3)$$

where D is the integration constant.

Kemball and Rideal[3] put $x = 1$ in this equation, when a direct test of its validity is simple. When x is unknown, equation (3) is not readily applied to the experimental results.

In the gaseous region, equation (3) becomes

$$\ln c = \ln \pi + D, \qquad (4)$$

that is, $c = \pi\beta$.

Subtracting (4) from (3) at corresponding concentrations,

$$0 = \frac{A_0}{kT}\pi + x \ln \pi - \ln \pi', \qquad (5)$$

where π is the measured pressure of the film and π' the pressure the film would have if it were perfectly gaseous. This equation is similar to the one used by Ward and Tordai[4] to calculate surface activities.

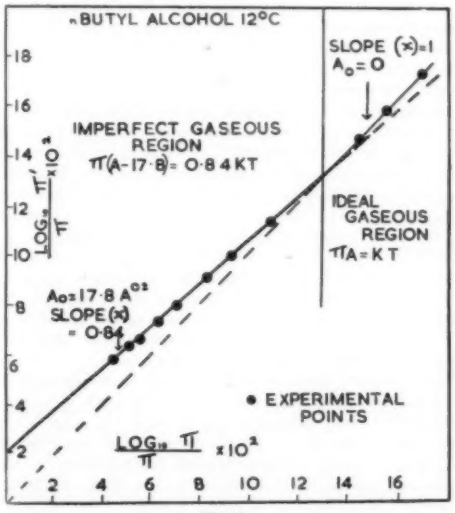

Fig. 1

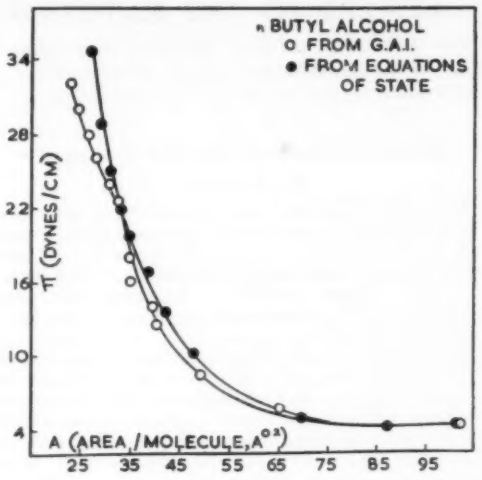

Fig. 2

Equation 5 can be rewritten as

$$\frac{\ln \pi'}{\pi} = \frac{A_0}{kT} + x\,\frac{\ln \pi}{\pi}.$$

Hence the plot of $\frac{\log_{10}\pi'}{\pi}$ (that is, $\frac{\log_{10} c/\beta}{\pi}$, β being obtained from the initial linear portion of the $\pi \sim c$ curve) against $\frac{\log_{10}\pi}{\pi}$ should be a straight line of slope x and intercept on the $\frac{\log_{10}\pi'}{\pi}$ axis of $A_0/2{\cdot}3\,kT$.

Fig. 1 shows such a plot for n-butyl alcohol at 12° C. The line has a slope of 0·84 and an intercept which gives a value of $A_0 = 17{\cdot}8$ A.^{2}. Values of x and A_0 were determined for a homologous series of normal aliphatic alcohols: x was found to decrease with increasing chain-length and A_0 to be independent of it.

For values of $\log_{10}\pi/\pi$ greater than 0·1 (π less than 10), the line coincides with that representing a gaseous film which has a slope of unity and intercept zero. When x is much less than unity, that is, the film is more condensed than the above one of n-butyl alcohol, the transition is much sharper than that shown in Fig. 1.

Fig. 2 compares the $\pi \sim A$ curve of n-butyl alcohol at 25° C. obtained from the equations of state

$$\pi A = kT \text{ (0–10 dynes/cm.)}$$
$$\text{and } \pi\,(A - 17{\cdot}5) = 0{\cdot}88\,kT \text{ (15–34 dynes/cm.)}$$

with that obtained by direct application of the Gibbs adsorption isotherm.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Effects of Radio-Frequency Voltages on Bacteria

NYROP[1], and Brown, Hoyler and Bierwith[2], have claimed that it is possible to destroy a large proportion of the bacteria in a liquid suspension at sub-lethal temperatures by the application of high radio-frequency voltage gradients. Attempts have been made to confirm these results in order to determine the factors involved.

Suspensions of *Bacterium coli* have been treated in a cell consisting of a section of glass tube, 2 cm. long and 0·9 cm. internal diameter, with a platinum electrode closing each end. The suspension was introduced and withdrawn through a small hole on the centre line of the cell. To minimize heating, dilute electrolyte such as 0·0005 *M* phosphate buffer or physiological saline diluted 1 : 100 has been used as the suspension medium. Voltages of up to 1,700 at a frequency of 30 Mc./s. have been applied to the cell.

To avoid purely thermal kills, it was thought desirable for the temperature of the suspension never to exceed 50° C. as a result of the treatment. Measurement of the temperature was soon found difficult, since the presence of a thermocouple during treatment caused local heating. Tests in which the couple was only introduced after the treatment period still showed wide variations in temperature caused by non-uniform heating.

These difficulties have been overcome by the use of a temperature-sensitive compound, silver tetra-iodomercuriate (Ag_2HgI_4), which changes colour reversibly from canary-yellow to red at 49° C. This compound is insoluble; but when in a finely divided form it can be suspended in the electrolyte by agitation. It has not been used in bacterial suspensions but in separate control experiments, and it raises the conductivity of the electrolyte by about the same amount as that resulting from the addition of bacteria.

Using this compound, the occurrence of non-uniform heating in the cell can be clearly demonstrated. The points at which maximum heating is obtained are always the same, although the degree of non-uniformity increases with increasing field strengths. At high values of the order of 850 volts/cm. conditions are such that, although a temperature of 50° C. is reached at points, the maximum temperature that can be measured in the suspension by thermocouple immediately after treatment is 36–40° C. The treatment time corresponding to these conditions is 0·5 sec.

The effect on the bacteria of treatment with radio-frequency voltages has been determined both by plate counts and by the increase in the turbidity of a broth inoculated with the test suspension, as measured photo-electrically. If the time of treatment is limited to that for which a temperature of 50° C. is not exceeded at any point, no lethal effect is found. Only when the treatment time is 50 per cent longer than this is any effect observed. It seems likely, therefore, that this effect is purely thermal.

The lethal effects reported by Nyrop and by Brown, Hoyler and Bierwith may have been due to highly localized heating of the kind detected by the temperature-sensitive compound in our experiments. Since the results of Nyrop and of Brown *et al.* were obtained after a series of pulses of voltage had been applied, it is possible that during the pulse periods there were considerable temperature variations which disappeared due to conduction and convection during the quiescent periods and so were not detected.

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April 18.

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A Photo-electric Method for Measuring Circular Dichroism

A RAY of plane polarized light, on entering an optically active medium, is resolved into two circularly polarized rays (one right-handed and the other left-handed) which travel at different speeds[1]. Cotton[2] found that, in solutions of potassium chromium tartrate, the circularly polarized rays are unequally absorbed, and the emergent light is elliptically polarized. He called the phenomenon 'circular dichroism', and studied it in two ways: (1) by direct experiments with circularly polarized light, and (2) by ellipticity measurements. Later workers, however, have confined their attention almost entirely to the second method. Ellipticity is now usually measured by means of a $\lambda/4$ plate (or Fresnel rhomb) mounted behind the polarizing system of a polarimeter, and with this simple apparatus many substances have been shown to exhibit circular dichroism.

Bruhat[3] was the first to express ellipticity in absorption units. If ε_l and ε_r are the molecular extinction coefficients for left- and right-handed light, respectively, and τ is the ellipticity (in radians), then for a solution containing c gm. mol. per litre in a tube l cm. long, $\varepsilon_l - \varepsilon_r = (4\tau \times 0{\cdot}4343)/lc$. When ε_l is greater than ε_r, the circular dichroism is taken as positive. Kuhn[4] extended ellipticity measurements into the ultra-violet, and introduced the term 'anisotropy factor' (g) for the ratio $(\varepsilon_l - \varepsilon_r)/\varepsilon$, which is important in asymmetric photochemical work[5]. In the middle of an absorption band, g has a maximum value (g_0) which is between 0·02 and 0·10 for most of the compounds studied. When $\varepsilon_l - \varepsilon_r$ is plotted against wave-length (λ), the points lie approximately on a probability curve the parameters of which can be used for calculating the related rotatory dispersion curve[6]. The procedure is not entirely satisfactory, however, since circular dichroism data are much less accurate than those of rotation. Better methods for measuring circular dichroism are required, and the photo-electric one now described should be useful when g is fairly large.

This method had its origin in a lecture experiment for demonstrating circular dichroism with a solution of caryophyllene nitrosite ($g_0 \simeq -0{\cdot}1$). The apparatus was essentially a photo-electric colorimeter[7] (which contained a Christiansen filter and a Weston photronic cell) with the addition of a large polarizing prism and a suitable $\lambda/4$ plate between the filter and

the cell for containing the solution. The experiment was carried out with a 1-cm. layer of caryophyllene nitrosite solution (1 per cent in benzene), the filter being adjusted to transmit light in the region of maximum absorption ($\lambda = 6750$ A.). First, the $\lambda/4$ plate was oriented to give left-handed light, and the indicator on the galvanometer scale was set to 35 cm. The $\lambda/4$ plate was then rotated through 90° (to give right-handed light) and the indicator was seen to move back about 5 cm. When a Zeiss–Winkel monochromator was used instead of the Christiansen filter, satisfactory readings were obtained only in the neighbourhood of 6000 A., so that greater over-all sensitivity was required. This is available in the Unicam spectrophotometer, and the instrument can be readily adapted for investigating circular dichroism.

The only additional apparatus required is an attachment (for producing circularly polarized light) which contains a Glan–Thompson prism and a $\lambda/4$ plate, the latter being selected for the required region of the spectrum. In the standard model of the Unicam instrument, there is a tubular opening (which contains a quartz lens) between the cell compartment and the exit slit of the monochromator. A brass tube (for holding the Glan–Thompson prism) is inserted behind the lens, and sufficient of the tube projects to provide a bearing on which the $\lambda/4$ plate holder can rotate. A metal plate (shaped to fit into the front of the cell compartment) is soldered to the tube to hold it in position and to carry stops for limiting the rotation of the $\lambda/4$ plate holder between $+45°$ and $-45°$ from the vertical. The optical components are then inserted so that, when the $\lambda/4$ plate is in the $+45°$ position, right-handed light is transmitted. It is also necessary to reduce the length of the cell carrier by about 1·5 cm.

Circular dichroism ($\varepsilon_l - \varepsilon_r$) is measured with the instrument in the following way. (1) Place the cell containing solution in the light beam. (2) Adjust the slit-width to give 100 per cent transmission (density = 0) for right-handed light. (3) Rotate the $\lambda/4$ plate through 90°. (4) Take the reading on the density scale. This value divided by lc gives $\varepsilon_l - \varepsilon_r$. If this should be negative, then the 100 per cent transmission setting is made with left-handed light.

Afterwards, a lever arrangement was added for rotating the $\lambda/4$ plate without opening the cell compartment, but this refinement is not essential.

When circular dichroism is obtained from ellipticity measurements (visual or photographic), accuracy is limited by the necessity of using quite dilute solutions. With the photo-electric method, much more concentrated solutions can be employed. A 1 per cent benzene solution of caryophyllene nitrosite in a 2-cm. cell showed a difference in transmission of 30 per cent when left-handed light ($\lambda = 6750$) was changed to right-handed. This result gives some idea of the magnitudes involved. The method has also the advantages of speed and simplicity of operation.

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May 2.

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[4] Kuhn, *Trans. Farad. Soc.*, **26**, 293 (1930).
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[6] See Lowry, "Optical Rotatory Power" (London, 1935).
[7] Mitchell and Cameron, *J. Chem. Soc.*, 1905 (1938).

Spectrographic Determination of a Major Constituent of a Solution

C. FELDMAN[1,2] has recently described a solution spark technique, wherein the solution under investigation is carried in an upper electrode consisting of a narrow graphite cup which has a porous base permeable to the solution, the lower electrode being a solid graphite rod.

The possibilities of adapting this technique for use with apparatus commonly available in Great Britain have been under examination by us, the aim being the determination of a major constituent—zinc—in solutions containing complementary amounts of copper and zinc.

Using the Hilger medium spectrograph and standard spark source, an analytical curve has been obtained from the line-pair Zn 2502·001/Cu 2544·802 for the range 10–90 per cent zinc, 90–10 per cent copper. A reproducibility test on a sample of Naval brass showed: average of 32 determinations, 36·1 per cent zinc; highest figure, 37·5 per cent, lowest figure, 35·0 per cent; standard deviation, 0·71 per cent—in terms of zinc content, 1·97 per cent.

On low-alloy brasses and solutions of copper and zinc over the range 25–45 per cent zinc, the accuracy of single determinations has been better than $\pm$ 2·0 per cent for the seventy-eight results so far obtained. 3·0 mgm. of brass suffices for an analysis in duplicate.

These results would seem to commend the method as having wide potentialities for extending the range of spectrochemical analysis.

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April 4.

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Crystal Structure of Ammonium Bicarbonate and a Possible Relationship with Ammonium Hypophosphate

PRELIMINARY work on the structure of ammonium bicarbonate was done by Mooney[1] in 1932, who reported that the space group was *Pccn*.

We have recently found the positions of the atoms in the structure. Approximate atomic co-ordinates, which may yet be modified slightly as a result of work which is in progress, are given below expressed as fractions of the unit-cell edges taking a centre of symmetry as the origin.

	x	y	z
C	0·0	0·24	0·16
O	−0·03	0·19	0·03
O	−0·03	0·19	0·28
O	0·06	0·35	0·17
N	0·25	0·01	0·41

These co-ordinates are consistent with the presence of planar CO_3 groups of the usual dimensions lying on either side of the diad axes with their planes inclined slightly to the bc plane of the unit cell. The CO_3 groups are joined in strings parallel to [c] by hydrogen bonds forming, as it were, polymeric anions. This is exactly similar to the hydrogen-bonded strings of CO_3 groups found by Zachariasen[2] in sodium bicarbonate; in other respects the structures of sodium and ammonium bicarbonates show minor differences.

In a recent letter by Raistrick and Hobbs[3] in which the structure of the hypophosphate ion was discussed, the space group and unit-cell dimensions of ammonium hypophosphate were reported. The figures are very similar to those given by Mooney for ammonium bicarbonate. The space group in each case is *Pccn*, and the unit-cell dimensions in the two cases are *a*,*b*,*c*: 7·26, 11·47, 9·38; and 7·29, 10·79, 8·76 A., respectively.

It is interesting to speculate on the possible relationship between the structures of these two compounds. It seems very likely that $P_2O_6^{4-}$ ions could have an external shape and size nearly the same as the shape and size of a pair of neighbouring CO_3^{2-} ions on either side of a diad axis in ammonium bicarbonate, the configuration being governed in each case by the close packing of six oxygen atoms. If this were so, the similarity in cell sizes and space-group symmetry would make it a reasonable speculation that the two structures were in some respects closely related; possibly the oxygen atoms, the ammonium ion and hydrogen bonds occupy similar positions in the cell. This possibility, which would not be difficult to check by structure work, seems to fit in well with Raistrick's choice of structure for the hypophosphate ion.

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May 6.

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Equivalence of Temperature and Frequency in Dielectric Measurements

One usual method of representing measurements of the complex dielectric constant is by a circular arc. Cole and Cole[1] pointed out that, if the dispersion and absorption of a dielectric could be represented by the empirical formula,

$$\varepsilon^* - \varepsilon_\infty = \frac{\varepsilon_0 - \varepsilon_\infty}{1 + (j\omega\tau_0)^{1-\alpha}}, \qquad (1)$$

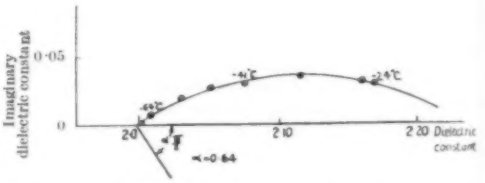
where ε^*, ε_0 and ε_∞ are the complex, static and infinite frequency dielectric constants respectively, τ_0 a generalized relaxation time and $\omega/2\pi$ the frequency of the applied electric field, then the dielectric constant – dielectric loss curve is the arc of a circle the centre of which is displaced below the real axis by an amount depending upon the constant α. If the dipoles in the dielectric are assumed to have a distribution of relaxation times, the distribution can be obtained from α.

This circular arc plot applies to the variation of the complex dielectric constant as a function of the frequency, which is not easy to determine experimentally. It is more usual to vary the temperature than the frequency, and to assume that changes in temperature are equivalent to changes in frequency. This equivalence follows from the theory of a dielectric model having a single relaxation time, but most dielectrics have a wide distribution of relaxation times. Even for these dielectrics, changes in the temperature are assumed to be equivalent to changes in the frequency. An example of this is Sillars's[2] investigation of the dielectric properties of a dilute solution of long-chain esters in paraffin-wax. The dielectric loss – frequency curves were considerably broader than a Debye curve, yet temperature and frequency were related by the equation,

$$\log (1/f_0) = ST_0 + C, \qquad (2)$$

where T_0 is the temperature at which the maximum occurs in the dielectric loss curve for a frequency f_0, and S and C are constants.

If temperature and frequency can be interchanged, and if the behaviour of the dielectric is represented by equation (1), then a circular arc plot would also be obtained if the temperature instead of the frequency were the parameter.



Variation of the complex dielectric constant with temperature of a mixture of $C_8H_{15}.CO.C_{11}H_{23}$ and $C_{17}H_{36}$ from −100° C. to −20° C. at 50 kc./s.

This method of analysis was applied to the variation with temperature of the complex dielectric constant of a mixture of a ketone and a paraffin, and the result is shown in the accompanying graph. The mixture consisted of 28 per cent by weight of the ketone $C_8H_{15}.CO.C_{11}H_{23}$ and 72 per cent by weight of the paraffin $C_{17}H_{36}$. A maximum of 16–18 per cent of the ketone can be dissolved in the paraffin by quenching the mixture from the melt, the remainder of the ketone being precipitated as a separate phase which is dielectrically inert. The results shown in the graph are for the mixture in the supersaturated condition. Measurements were made with a Schering bridge at 50 c./s., 800 c./s. and 50 kc./s. over the temperature range −100° C. to −20 °C. The same value of α, 0·64, was obtained at all three frequencies, and therefore only the results obtained at 50 kc./s. are shown.

A similar analysis of Powles's[3] results for the transition in solid hydrogen bromide, a material which differs widely from that which I have used, also gave a circular arc diagram with temperature instead of frequency as the parameter. The value of α was 0·52 at 1 kc./s. as compared with 0·21 at − 196·2° C. for the normal circular arc plot.

For both these substances, the locus of the dielectric constant in the complex plane is a circular arc with the centre of the arc considerably displaced below the real axis. This gives, therefore, experimental evidence for the equivalence of frequency and temperature for a dielectric with a wide distribution of relaxation times. No theoretical explanation for this equivalence in the presence of a wide distribution of relaxation times has yet been given.

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Hyperfine Structure and Saturation Effects in the Paramagnetic Resonance Spectrum of Manganese

A MICROWAVE bridge in conjunction with a superheterodyne method of reception has been used for the detection and measurement of weak paramagnetic resonances. It has been possible to investigate, at a frequency of 9,501·5 Mc./sec., the resonance spectrum of Mn^{++} ions contained, in concentrations down to 1 part in 10^5, as activators in zinc sulphide phosphors.

By means of a 50 c./sec. field modulation the magnetic absorption at room temperature is displayed as a function of magnetic field. For the specimen with a concentration of 1 per cent manganese the resonance absorption curve is similar in shape but narrower (width approximately 300 gauss) than that for hydrated manganese sulphate crystals[1]. A reduction of 'exchange narrowing' may account for the greater overall width of the resonance observed for the next lower concentration of 0·1 per cent manganese. The more interesting feature of the decrease in concentration is, however, the appearance of a hyperfine structure shown by a splitting into six peaks in agreement with the spin of 5/2 for the manganese nucleus. An additional structure is just detectable at this concentration.

The spectrum for the lowest concentration (0·001 per cent Mn) is shown in Fig. 1 and has been examined in more detail by reducing the sweep amplitude and photographing in sections for different static magnetic fields. The complete structure is reproduced diagrammatically in Fig. 2; the magnetic fields corresponding to the individual peaks have been obtained by calibration against proton resonance.

The six main peaks of the complex spectrum are spaced at intervals of 66·2, 66·9, 67·6, 68·3 and 71·5 gauss, corresponding to a hyperfine structure interval of 0·006 cm.$^{-1}$, of the same order as that obtained for copper and cobalt[2,3]. The interpolated centre of this series lies at 3,384·2 ± 0·5 gauss and corresponds to a g factor, after correction for the shift introduced by the hyperfine splitting, of 2(1·0012 ± 0·0002). This figure agrees satisfactorily with the electron spin g value of 2(1·00119 ± 0·00005) obtained by Kusch and Foley[4] from atomic beam experiments. The subsidiary structure of the spectrum results from a second-order splitting of the $^6S_{5/2}$ ground state of Mn^{++} by the crystalline electric field[5]. In the absence of detailed information on field symmetry and measurements with single crystals, no detailed analysis is possible; but the diagram indicates a possible grouping into five series, corresponding to an initial splitting of the order of 0·002 cm.$^{-1}$.

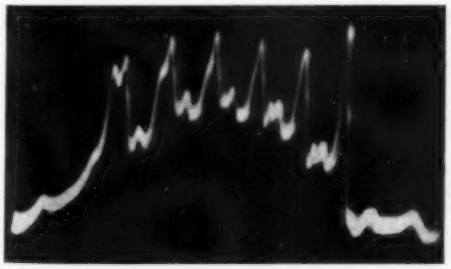

Fig. 1

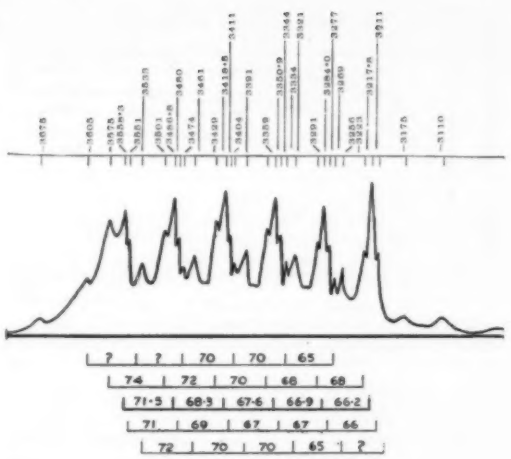

Fig. 2

Experiments at liquid-air temperature, using the phosphor with the lowest manganese concentration, have shown that the general structure of the spectrum is not materially different from that at room temperature, which indicates that the width of the lines is predominantly determined by spin-spin interaction. However, the low-temperature measurements have yielded information on the spin-lattice relaxation. In contrast with the high powers required for investigations on paramagnetic salts[6] the power-level available from the reflex klystron (100 mW.) has been adequate for the study of relaxation effects in the magnetically dilute phosphor. A saturation effect, indicated by a decrease with increasing input of the ratio of magnetically absorbed power to input power, has been clearly established, and from quantitative measurements a value for the spin-lattice relaxation time of 10^{-6} sec. has been obtained.

We are greatly indebted to Dr. G. F. J. Garlick, of the University of Birmingham, for the supply of phosphor specimens.

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Gelation of Montmorillonite

THE combination of optical and elastic studies on sols of Wyoming bentonite containing the smallest particle sizes (15–20 mμ equivalent spherical diameter) have led to the conclusion that the gelation of this system is due to the formation of a fibrillar network in which the plates are aggregated end-to-end in the form of flat, ribbon-like filaments. The growth of these aggregates is indicated in Fig. 1, which shows the increase in the dissymmetry coefficient of the scattered light, and hence an increase in the size

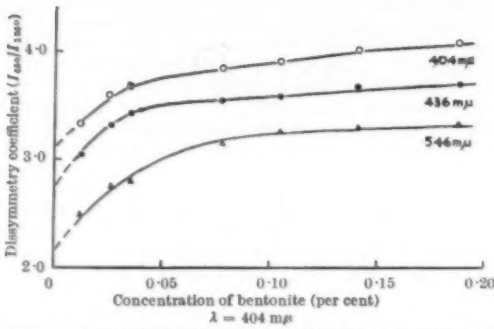

Fig. 1. Variation of the dissymmetry coefficient of the scattered light with particle concentration

of the scattering unit, with increasing particle concentration. The values of the dissymmetry coefficient at infinite dilution correspond to rectangular plates of mean semi-perimeter 300 mμ, while the limiting values of the coefficient at the higher concentrations correspond to long flat filaments of mean width 100 mμ. On account of the irregularity in the particle size and shape, and the probability of incomplete aggregation, these estimates agree as well as can be expected with the mean values of 338 mμ and 150 mμ obtained from electron micrographs of the particles in our sols. The filamentary nature of these aggregates is confirmed by the angular intensity distribution of the scattered light, which fits closely to the theoretical curve.

The spontaneous birefringence which is observed when these sols are placed in cylindrical tubes and annuli is due to a tendency for the aggregates to become orientated perpendicular to the wall.

An investigation of the effect of the addition of uni- and di-valent electrolytes upon the rigidity has enabled us to discriminate, for this system, between the random-mesh[1] and the electrical theories[2] which have been proposed to explain the gelation of a lyophobic sol. According to the random-mesh (or contact) theory, the addition of an indifferent electrolyte should have little effect; whereas on the electrical theory, the rapid compression of the electrical double layer should result in a marked increase in the rigidity. The effect of the addition of sodium

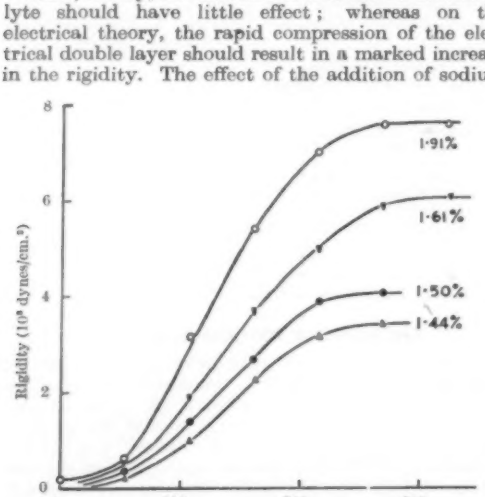

Fig. 2. Effect of univalent electrolyte upon the rigidity of bentonite sols of different concentrations

hydroxide is shown in Fig. 2; after the addition of about 50 millimoles per litre, preferential adsorption of ions ceases, and the fact that the rigidity increases most rapidly in the later stages is strong evidence for the electrical theory. The subsequent decrease in slope at about 180 millimoles per litre is due to the onset of irreversible flocculation, which is characterized by the appearance of a sudden opacity and 'stickiness' in the previously clear gel.

Taking as the elastic model a network of particles aggregated end-to-end, it can be shown that, for small strains, the rigidity is given by the expression $G = f(N,\alpha)\ d^2V/dx^2$, where V is the total potential energy of two particles situated a distance $2x$ apart and $f(N,\alpha)$ is a function depending upon the angular distribution of the filaments about the normal to the plane of shear. From potential-energy curves constructed on the basis of the recent theory of Verwey and Overbeek[3], the variation of the second differential coefficient at the potential minimum with increasing electrolyte concentration has been determined and the above expression verified experimentally.

We are indebted to Geochemical Laboratories for the gift of the Wyoming bentonite used in this work, a complete account of which will be given elsewhere.

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Iron Intake and Hæmochromatosis in the Bantu

THE high incidence of hæmochromatosis among the Bantu was initially pointed out by Strachan[1], and has been confirmed by the Gillmans[2,3], who regard the disorder as one of the manifestations of chronic malnutrition.

In a recently published paper, Kinney, Hegsted and Finch[4] have reported, *inter alia*, that: (*a*) when rats were fed on an adequate diet together with 2 per cent iron citrate, no deposition of hæmosiderin occurred in the liver; (*b*) when a diet of 80 per cent corn grits and 20 per cent lard was used, there was slight deposition of hæmosiderin in that organ; (*c*) but when this latter diet was supplemented with 2 per cent iron citrate, massive deposition resulted. Only, therefore, when the diet was inadequate in many respects and also contained added iron was the accumulation of this element in the liver observed. The general pattern of the distribution of iron in the tissues of the rats was stated to be similar to that observed in the Bantu subjects. Since the diet of the Bantu usually contains a large amount of maize, the above considerations have prompted inquiry as to the level of the daily iron intake of these people. The purpose of this communication is to provide evidence that an unusually large amount of iron is, in fact, frequently ingested in their food.

It has been stated that the diet of the African is not particularly rich in iron[2]; but a daily diet including maize to provide, say, 2,000 calories contains 15–30 mgm. iron, thus probably more than covering the generally recommended allowance of 10–15 mgm.[5]. The intake of this element, however, is greatly increased during the preparation of food for consumption, for the Bantu, both in rural and urban areas, very frequently use iron pots for cooking purposes. It has been found that in the cooking of whole maize, maize meal porridge, various types of legumes, and in the preparation of kaffir beer and fermented porridge or 'marewa', the iron content may be increased up to at least five times that contained in the original foodstuffs. A typical diet cooked in the traditional manner may contain 100–150 mgm. iron per diem. When large numbers of Bantu are fed in a communal manner, large iron cooking vessels are also used. Analyses for iron content of the adequate diets consumed have been undertaken at certain centres: the daily food ration of the Bantu workers on the gold mines and at this Institute has given values of 100–150 mgm. iron per diem; while values of about 100 mgm. per diem have been obtained in the food intake of Bantu prisoners at the Johannesburg Gaol.

Confirmation of the large amounts of iron being ingested by these people has been obtained by determining the iron content of their fæces. In the case of the gold mine Bantus (three-day periods) and the Institute Bantus (one-day periods), the amounts of iron voided varied from 75 to 145 mgm. per diem; for the gaol Bantus (seven-day periods), the amounts varied from 65 to 105 mgm. per diem. Far less accurate but confirmatory evidence has been obtained by determining, with suitable precautions, the iron content of stools of rural Bantu collected at kraals in the countryside near Johannesburg; values from 40 to 215 mgm. per stool were obtained. Urines, collected for 24-hour periods, from subjects at the above centres, all contained less than 0·7 mgm. iron per diem. Balance experiments for weekly periods have been carried out on the Bantu prisoners at the gaol, when consuming their everyday food; since, however, the homogenization of food before consumption was not carried out, the iron-intake figures, and hence the iron-retention figures, are not reliable.

It is obvious from experiments both on animals and man that a high intake of iron is not the cause of hæmochromatosis. Nevertheless, the study of Kinney *et al.*[4] showed that, in the unsatisfactory dietary setting used, such an intake was of critical importance in promoting the development of the disorder. It is therefore suggested that with the particular type of malnutrition affecting the Bantu, the relatively large amount of iron habitually ingested may be an etiological factor in the hæmochromatosis reported to be so common among them.

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Keratins in Invertebrates

If the term 'keratin' were applied only to those proteins which contain a high proportion of cystine, which give a keratin-type of X-ray diffraction photograph and which dissolve with ease only in alkaline solutions of reducing agents, then keratins, so far as is known, are confined to the epidermis and epidermal appendages of vertebrates, and are always intracellular. Other so-called keratins from vertebrate egg capsules[1,2], byssus threads of *Mytilus*[3], etc., though they contain cystine, can be dissolved by solvents other than alkaline reducing agents, do not give a keratin-type of X-ray photograph and are extracellular structures.

A few intracellular protein structures are, however, known to occur in invertebrates, and some of them have been examined to see if they are chemically allied to keratin. No X-ray photographs were obtained, but cystine was tested for histochemically by the method of Chèvremont and Frederic[3]. No cystine could be demonstrated in the central capsule membrane of the radiolarian *Thalassicola*, nor in the rhabdites of the turbellarians *Planaria* and *Dendrocœlum*. In the nematocysts of the cœlenterate *Corynactis viridis* and in the epidermal supporting fibres of the echinoderm *Asterias rubens*[4], it was possible to demonstrate the presence of cystine, and the nemocysts were dissolved only by alkaline sodium sulphide solution. While this evidence does not prove that the structures are composed of keratin, it suggests that they might be. These results are of further interest because of the suggested evolution of the vertebrates from an echinoderm stock.

This work was carried out at the Zoological Laboratory, Cambridge, and Stazione Zoologica, Naples.

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Enzymatic Synthesis of Citrate from Pyruvate and Oxalacetate

Soluble enzyme preparations from *Escherichia coli* and *Streptococcus fœcalis* catalyse the dismutation of two molecules of pyruvate to acetyl phosphate, lactate and carbon dioxide when orthophosphate is present. Acetyl phosphate was determined by Lipmann's hydroxylamine reaction[1]. The system is almost inactive in the absence of added diphosphopyridine nucleotide (DPN). Maximum reaction-rates require, in addition to enzyme, substrate and pyridine nucleotide, the following components: orthophosphate, magnesium ions (Mg^{++}) or manganese ions (Mn^{++}), diphosphothiamine, a boiled extract of yeast, and lactic dehydrogenase. Coenzyme *A* is required for maximum yields of acetyl phosphate. The nature of the active factor in yeast extract is unknown; but it is not coenzyme *A*. It is possible that the compound may be a coenzyme form of the factor of O'Kane and

Gunsalus[2] required for oxidative decarboxylation of pyruvate by *S. fæcalis* cells. In the absence of orthophosphate, the reaction-rate is sharply reduced and no acetyl phosphate accumulates. The dismutation can be formulated as follows:

(1) Pyruvate + phosphate + DPN_{ox} → acetyl phosphate + CO_2 + DPN_{red}
(2) Pyruvate + DPN_{red} → lactate + DPN_{ox} (*lactic dehydrogenase*)

Sum: 2 Pyruvate + phosphate → acetyl phosphate + CO_2 + lactate.

Reaction 1 is an over-all reaction which may involve at least two enzymes. There is no evidence that pyridine nucleotide is the primary hydrogen acceptor.

The primary dehydrogenation reaction may result in the formation of an acetyl-enzyme or acetyl-coenzyme intermediate which, in the presence of another enzyme, may be cleaved either (*a*) by phosphate with formation of acetyl phosphate, or (*b*) by oxalacetate with formation of citrate as indicated in the accompanying scheme. The hypothetical

Pyruvate + coenzyme $\xrightarrow{-2H}$ acetyl-coenzyme + CO_2

$$-P \swarrow\!\!\nearrow +P \qquad -OAA \searrow\!\!\nearrow +OAA$$

(*a*) acetyl-P + coenzyme (*b*) citrate + coenzyme

coenzyme may be coenzyme *A*. Reaction (*a*) is probably catalysed by Stadtman's transacetylase[3], reaction (*b*) by the condensing enzyme[4]. This formulation is supported by the finding that both *E. coli* and *S. fæcalis* extracts form citrate at a good rate *in the almost complete absence of orthophosphate*, provided the pyruvate dismutation system is supplemented with oxalacetate and condensing enzyme. Typical results are shown in the accompanying table.

Bacterial enzyme	System	*A* Micromoles of citrate formed per ml. 5 min.	10 min.	20 min.	40 min.	*B* Micromoles formed per ml. in 40 min. CO_2	Acetyl phosphate
E. coli (6 mgm. of protein)	Complete		0·61	1·42	3·02	2·9	1·62
	No phosphate*		0·64	1·51	3·38	0·6	~0·1
	No phosphate, no coenzyme *A*		0·16	0·34	0·58		
	No phosphate, no DPN				0·09		
	No DPN					0·2	~0·1
	No condensing enzyme	*			1·06		
S. fæcalis (7 mgm. of protein)	Complete	0·47	0·88	1·82	3·34		3·2
	No phosphate†	0·66	1·21	2·30	4·65		0·3
	No phosphate, no DPN				1·35		
	No DPN						1·0
	No condensing enzyme				0		

* Orthophosphate present in reaction mixture, 0·06 micromoles per ml.
† Orthophosphate present in reaction mixture, 0·08 micromoles per ml.

(*A*) The complete system contained per ml.: potassium phosphate buffer *p*H 7·4, 50 micromoles; sodium bicarbonate, 20 micromoles; L-cysteine, 10 micromoles; magnesium chloride, 2·4 micromoles; manganese chloride, 1·6 micromoles; coenzyme *A*, 5 units; DPN, 100 γ; cocarboxylase, 50 γ; pyruvate, 50 micromoles; oxalacetate, 20 micromoles; crystalline condensing enzyme, 50 γ. Gas phase, 5 per cent carbon dioxide and 95 per cent nitrogen; temperature, 25°.

(*B*) Same as *A*, except for omission of oxalacetate, condensing enzyme and bicarbonate in all samples, and addition of 20 micromoles of *tris* (hydroxymethyl) amino methane buffer *p*H 7·4 in samples without added orthophosphate. Gas phase, nitrogen; temperature, 25°.

Bacterial enzymes: Lyophilized *E. coli* (4157) ground with an equal weight of Alumina *A* 301, -325 mesh (Aluminium Co. of America) and extracted with 10 volumes of 0·9 per cent potassium chloride containing 0·01 *M* L-cysteine. Mixture centrifuged at 13,000 r.p.m. and 0° for 30 min. and supernatant dialysed 48 hr. at 2° against 0·9 per cent potassium chloride containing 0·005 *M* L-cysteine. *Streptococcus fæcalis* (10*C*1) acetone powder extracted as *E. coli* and dialysed for 24 hr.

It will be noticed that while the *E. coli* extract used contained limiting amounts of condensing enzyme, the *S. fæcalis* preparations were completely devoid of it. It is significant that orthophosphate produced a small but definite inhibition of citrate synthesis, which was probably due to competition between reactions (*a*) and (*b*). The *S. fæcalis* extracts contain a very active enzyme system catalysing the conversion of two molecules of pyruvate to one of acetylmethylcarbinol and two of carbon dioxide[5]. For this reason the production of carbon dioxide is not a measure of the dismutation alone in this case and has been omitted from the table.

Our results explain the observation that pyruvate is not removed aerobically in dialysed heart homogenates unless a dicarboxylic acid (which can be oxidized to oxalacetate) is present[6]. If the heart preparations do not contain enzyme (*a*), there can be no disappearance of pyruvate, even in the presence of orthophosphate, unless oxalacetate is available. Heart and other animal tissues do not contain transacetylase; but they contain large amounts of condensing enzyme.

We wish to thank Miss Alice del Campillo and Mr. Tibor Farkas for assistance. We are greatly indebted to Dr. W. F. Verwey, Medical Research Division, Sharp and Dohme, Inc., for a generous supply of lyophilized *E. coli* cells. The work was supported by grants from the United States Public Health Service, the American Cancer Society (recommended by the Committee on Growth of the National Research Council), the Office of Naval Research, and the Rockefeller Foundation.

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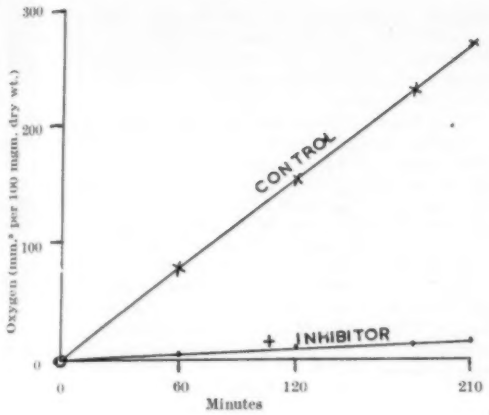
A Germination Inhibitor from Sugar Beet

Tolman and Stout[1] conclusively demonstrated the presence of water-soluble substances in the seed coat of sugar beet, which inhibited its germination. Later[2], they claimed that the toxic action of the water-extract of the beet seed cluster was due to a hydrolytic enzyme, which liberated free ammonia in toxic quantities from nitrogenous substances present in the water extract. Dutch workers[3] claimed that the inhibition of germination was due to the osmotic pressure exerted by inorganic substances present in the seed coat. They could obtain no ether-extractable substance which inhibited germination.



Using peroxide-free 'Analar' ether, thrice distilled in all-glass apparatus, we have obtained from the water-extract of beet seeds an unsaturated yellow oil, which acts as a powerful germination inhibitor when tested on cress (*Lepidium sativum*) and other seeds. The inhibitor seems to exert a specific influence on seedlings, its effect being most marked on the radicle (see table).

Ether extract (p.p.m.)	Hypocotyl fresh wt. per 100 seeds (gm.)	Radicle fresh wt. per 100 seeds (gm.)	Total wt. of seedlings (gm.)	% Germination after 6 days	Ratio radicle/hypocotyl
100	0·596	0·126	0·522	82	0·31
50	0·619	0·170	0·789	90	0·26
10	0·735	0·277	1·012	100	0·37
Control	0·793	0·391	1·184	100	0·49

In attempting to elucidate the physiological action of the inhibitor, respiration studies were carried out on hand-cut sections of sugar beet in a Warburg apparatus. Using fourteen disks of 1 cm. diameter per vessel suspended in 2·5 ml. *p*H 5·5 Sorensen's phosphate buffer and potassium hydroxide in the centre cup, results were obtained as expressed in the accompanying graph.

The inhibitor markedly affects the rate of oxidation of catechol by the polyphenolase enzyme of sugar beet. It apparently does not affect other enzyme systems. Inhibition of the cress seedlings can be reversed by washing, and they then germinate very rapidly. It is thought, therefore, that glycolytic reactions continue in the inhibited seed, so that, when the inhibitor is removed by washing, abundant energy becomes available for growth.

This work will be published in full elsewhere. We wish to thank the Carnegie Research Fund for a grant in aid for apparatus.

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Effect of D-Tubocurarine Chloride and Carbaminoylcholine on the Respiration of *Daphnia*

MEASUREMENTS of the respiration of *Daphnia* were made by a modification of the Cartesian diver micromanometer[1]. With D-tubocurarine chloride, decrease of respiration and movement begins in a concentration of 2 mgm./100 ml. At 25 mgm./100 ml. paralysis is complete and respiration diminished by 32 per cent; increasing the concentration to 150 mgm./100 ml. produces no further inhibition of respiration. Thus it appears that the diminution of respiration is due to the loss of muscular activity, which accounts for 32 per cent of the total respiration. This proportion is found to be the same in *Daphnia* with normal respiratory-rates ranging from 0·23 to 0·56 c.mm. oxygen/individual/hr.

Carbaminoylcholine increases respiration and movement in a concentration of 0·01 mgm./100 ml. The increase of respiration reaches a maximum of 190 per cent normal between the concentrations of 1 and 10 mgm./100 ml., when movement is considerably increased. Higher concentrations produce smaller increases of respiration and partial paralysis.

The results with D-tubocurarine show that, in normal *Daphnia*, the oxygen consumption associated with muscular activity bears the proportion 32 : 68 to oxygen otherwise consumed. If the maximum increase to 190 per cent normal, produced by carbaminoylcholine, is due to increased muscular activity, this proportion becomes 122 : 68. It is therefore concluded that, when exerting its maximum effect on respiration, carbaminoylcholine increases by approximately four times the oxygen consumed in association with muscular activity.

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Distribution of the Protective Factors for Vitamin C in Fractions of Liver Homogenates of the Rat

IT has been reported by de Caro and Giani[1], Mawson[2] and Giri and Shouri[3] that animal tissue extracts contain factors which protect vitamin C against oxidation. These protective factors were found to be of the nature of thiols[1]. Mawson observed that liver extracts from which glutathione was removed by prolonged dialysis retained the protective properties of fresh extract and concluded that glutathione is not the only constituent responsible for the protective mechanism existing in animal tissues. Later, Giri and co-workers[4] reported that certain purines such as xanthine, uric acid, adenine, guanin, theophylline and nucleic acids exert a protective action on vitamin C against oxidation. Since purines and nucleic acids are widely distributed in cells, it seemed of interest to find out the distribution of the protective factors for vitamin C in various fractions of liver homogenates, in the hope of gaining an insight into the nature of the factors responsible for the protective action.

Rat liver was homogenized with about two volumes of ice-cold hypertonic sucrose solution by means of a Potter–Elvehjem homogenizer, and the fractiona-

tion was carried out by the technique described by Hogeboom *et al.*[5], which involves fragmentation of the cell and differential centrifugation. All the fractions were made up to the same volume as the original homogenate (10 c.c.), except the unfractionated residue, which was made up to 20 c.c., and 1 c.c. of each of the fractions and 2 c.c. of the residual fraction were added to the reaction mixture containing vitamin C (10 mgm.) and phosphate buffer *M*/45 (*p*H 7·4). The protective effect of each of the fractions was determined by incubating the reaction mixtures at 37° C. and estimating the vitamin at known intervals of time by titration with the indophenol reagent.

In the accompanying table are given the results of a typical experiment.

INHIBITION OF THE OXIDATION OF VITAMIN C AT *p*H 7·4 BY THE VARIOUS FRACTIONS OF LIVER HOMOGENATES OF THE RAT

Liver fraction	Vitamin C (mgm.) after 0 hr.	1 hr.	2 hr.	4 hr.	20 hr.
Vitamin C alone (control)	10·0	6·3	3·6	0	0
Vitamin C + original homogenate	10·0	9·8	9·2	8·1	3·4
Vitamin C + nuclear fraction	10·0	9·8	9·2	8·1	2·7
Vitamin C + mitachondrial fraction	10·0	10·0	9·8	9·7	6·1
Vitamin C + unfractionated residue	10·0	10·0	9·8	9·7	7·3

The results show that all the fractions of liver homogenate inhibit the oxidation of the vitamin, the protective action exerted by the mitachondrial fraction and the unfractionated residue being somewhat more than that exerted by the original homogenate and the nuclear fractions. This suggests that the homogenate contains also factors which oxidize the vitamin, and that these oxidative factors are mostly present in the nuclear fraction. Further work on the nature of these factors and the mechanism responsible for their protective action is in progress.

I acknowledge the kindness of Prof. Hans von Euler for making available the facilities of this Institute for carrying out these investigations.

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Anaerobic Subcutaneous Emphysema of Poultry

IN poultry and pigeons, subcutaneous emphysema is known as a disorder caused by air escaping from the respiratory system (air sacs, lungs and trachea). In such cases, the escaped air accumulates in the subcutis and inflates the skin. This condition can be improved by repeated puncturing of the skin and by expressing the air.

During 1949 and the beginning of 1950, many cases of emphysema with very marked 'ballooning' were received at this Laboratory. The condition could not be corrected by repeated puncturing of the skin. Post-mortem examination of these cases revealed changes in the subcutis and muscles, which closely resembled those encountered in infections caused by anaerobes. Indeed, bacteriological and microscopical examinations proved that this disorder was caused by a mixed infection of *Clostridia* and cocci.

Very little is known, and less even published, about clostridial infection in poultry. Most references deal with single and accidental cases and not with a disease of widespread occurrence. According to our observations, the disease in southern Israel usually appears in the form of a few sporadic cases on different farms, and involves several areas.

In all cases only young birds aged four to sixteen weeks were affected, and *Clostridium welchi*, accompanied sometimes by *C. tertium*, was isolated. In most of the fowls thus affected, the disease terminated in death. We believe that infection occurs through skin wounds.

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Direct Isolation of D-Deoxyribose by Mercaptanolysis of Calf Thymus Deoxyribonucleic Acid

THE identity of 2-deoxyribose as a carbohydrate constituent of thymus nucleic acid was demonstrated by Levene. Using acidic hydrolysis[1] and enzymic methods[2], it was possible to prove that 2-deoxyribose was combined with the purine residues in the nucleic acid, though the nature of the sugar combined with the pyrimidine moiety is still uncertain[3].

The problem has now been re-investigated in the light of recent developments. Stacey *et al.*[4], working with sperm nucleic acid, found that the substance is very sensitive to acidic reagents, and there was evidence that at least some of the sugar units may possess highly labile aldehydo linkages, and that methyl acetal-like substances are formed when the nucleic acid is degraded by methanolic hydrogen chloride. It has now been found that calf thymus nucleic acid behaves in a similar manner toward acidic reagents, and it appeared worth while to attempt the isolation of a deoxy sugar component as a crystalline derivative of the aldehydo form. Experiments were carried out on fibrous calf thymus nucleic acid provided by the courtesy of the late Prof. J. M. Gulland. Since the dibenzylmercaptal of 2-deoxyribose is stable under acid conditions[5], concurrent hydrolysis and mercaptylation were carried out with aqueous hydrochloric acid and toluene-ω-thiol at − 5° C. (or with toluene-ω-thiol saturated with hydrogen chloride) in the following manner. The nucleic acid (0·5 gm.) was finely dispersed and stirred with toluene-ω-thiol (0·5 c.c.) at − 5° C. Strong hydrochloric acid (0·5 c.c., density 1·1) was slowly added, with vigorous stirring, to the mixture. The nucleic acid appeared to swell and then to assume a white gum-like form. After four hours, the reagents were separated from the mercaptylated product, which was then washed alternately with water, acetone and ether to remove excess reagents. The solid was treated with ammonium hydroxide (5 c.c., 5 *N*) at room temperature for 30 min. and then evaporated to dryness, under diminished pressure, at

room temperature. The product was extracted with dry ether. Evaporation of the ether extract yielded a crystalline solid (53 mgm.) which was recrystallized from ether–ligroin: $[\alpha]_D^{23} + 12{\cdot}8°$ (in chloroform, *c.* 0·47); melting point 66–67° C. alone or in admixture with an authentic specimen of 2-D-deoxyribosedibenzylmercaptal[5] (found: C, 62·1; H, 6·6; S, 17·1 per cent; calc. for $C_{19}H_{24}O_3S_2$, C, 62·6; H, 6·7; S, 17·6 per cent). The identity of this derivative was further demonstrated by its positive reaction after treatment with a trace of mercuric chloride solution towards the Dische reagent[5,6].

For comparison, D-ribose dibenzylmercaptal was synthesized from D-ribose (presented by Hoffman–La Roche Inc.) by reaction with toluene-ω-thiol and concentrated hydrochloric acid at room temperature. The product, recrystallized from chloroform–ligroin, had melting point 121–123° C., $[\alpha]_D^{19} - 139{\cdot}8°$ (in chloroform, *c.* 0·26); (found: C, 60·1; H, 6·19; S, 16·60 per cent. $C_{19}H_{24}O_4S_2$ requires C, 59·91; H, 6·32; S, 16·85 per cent).

Examination of the insoluble residue showed that it was still a large molecule containing phosphorus and nitrogen, and that benzyl mercaptal groups had entered the molecule. This material gave a positive Dische test and is being investigated further.

I am indebted to Princeton University, New Jersey, for the award of a Rockefeller Foundation Fellowship and to Profs. E. S. Wallis and E. Pacsu for their interest in the work.

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A Factor influencing the Intracellular Exposure of Sulphydryl Groups

IN the course of some experiments involving the addition of solutions of sulphydryl inhibitors to cultures of *Paramecium bursaria*, it was noticed that a wide range of response was obtained from concentrations just below a lethal level. Further examination has shown that the period of survival of any one culture when exposed to a given concentration of a sulphydryl inhibitor is dependent upon the illumination of the culture, both immediately before and during the experiment.

Experimental studies have been undertaken using as a standard source of illumination a mercury vapour lamp screened with a glass filter opaque to radiations of less than 3300 angstroms. The stock culture of *Paramecia* from which all experimental samples were drawn was kept in the dark, and all experiments were carried out in a darkened room. Examinations of the cultures were made with the aid of a low-powered bulb screened with a Wratten IIA filter.

Preliminary experiments showed that regularly repeatable results could be obtained with the standardized conditions of illumination. Results obtained with a number of sulphydryl inhibitors are given in the accompanying table. The first row gives the times in minutes for the death of 90 per cent of the cells in the culture when maintained in the dark after addition of the sulphydryl inhibitor. The second row is the corresponding figure for cultures irradiated for 15 min. immediately prior to the addition of the inhibitor; these cultures were then kept in the dark. The third row gives the results obtained when the cultures were exposed to the lamp after addition of the inhibitor.

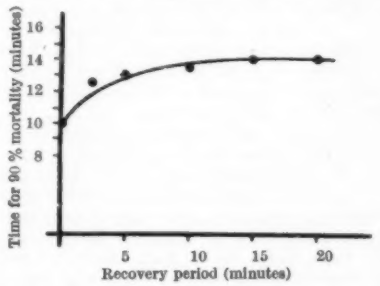
Times, in minutes, for death of 90 per cent of cells under varying conditions. Concentrations are those in final cultures after addition of inhibitor

	Iodoacetic acid 5×10^{-4}	Iodoacetic acid $6{\cdot}6\times10^{-4}$	Monochloracetone $3{\cdot}3\times10^{-4}$	Maleic acid 5×10^{-4}	Mercuric chloride 1×10^{-4}	Propionaldehyde 5×10^{-4}
In dark	32	23	45	—	14	48
15 min. radiation	30	19	45	—	10	47
Under lamp	14	10½	16	45	6	15

The time-period of 15 min. for irradiation used in the above experiments was arbitrarily chosen after a series of experiments had shown that any effect obtained increased with periods of irradiation of up to 15–20 min.; but that prolongation beyond this had no further effect. In the case of maleic acid, it was not found possible to determine a concentration which would kill the culture in any period greater than about 3 min. unless exposed to the lamp.

The possibility of the above effects being due to the presence of a photosensitizing agent in the medium or the cells themselves must be discounted, since control cultures survive indefinitely the radiation from the lamp in the absence of a sulphydryl inhibitor. Equally, the effect of radiation prior to the addition of an inhibitor rapidly reaches a maximum and then remains unaltered. This also is against the presence of a photosensitizing agent, but suggests an intracellular effect which is brought up to and held at a specific level as a consequence of the radiation. If this is correct, it is to be anticipated that a period of darkness after irradiation and prior to the addition of the inhibitor would tend to recovery to the normal state. Experimentally this is found to be so; recovery occurring in about 15–20 min. A typical curve illustrating the phenomenon is shown in the accompanying graph.

It must be presumed that the death of the cells used in these experiments occurs when some specific level of inhibition of functional sulphydryl groups is reached. Since the radiation cannot be presumed to



Recovery from irradiation. Mercuric chloride: 1×10^{-4}. Non-irradiated controls gave, as a mean of six results, 14½ min.

have any influence on the rate of penetration of the inhibitors into the cells, the more rapid occurrence of death under the conditions of irradiation must be due to a greater availability of sulphydryl groups. In other words, radiation with wave-lengths greater than 3300 A. causes an increased exposure of intracellular sulphydryl groups.

This conclusion, together with its obvious corollary, of increased cellular susceptibility to attack through its functional systems dependent upon sulphydryl, may offer an explanation for the well-known avoidance of strong light by such free-living organisms as *Paramecia*. In addition, the above findings are of importance with regard to the mechanism of photodynamic action. This latter point will be discussed in detail elsewhere.

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An Exchange between Free Purines and Pyrimidines and the Aglucones of Deoxyribosyl Purines and Deoxyribosyl Pyrimidines

THE ability of a single deoxyriboside to support growth of several species of bacteria has prompted us to investigate the mechanism of deoxyribosidic interconversion in these organisms. An arbitrary system was adopted which consists of two parts: (1) a crude enzyme preparation from one such organism (*Lactobacillus helveticus*); (2) measurement of the quantity of deoxyriboside (synthesized or destroyed) by microbiological assay with another such organism (*Thermobacterium acidophilus* R_{26}). The enzyme preparation contained neither adenine deoxyriboside deaminase nor cytosine deoxyriboside deaminase.

Purine deoxyribosides were differentiated from pyrimidine deoxyribosides by virtue of the resistance of the latter to mild acid-hydrolysis[1]. Individual deoxyribosides were separated by chromatography on paper using *n*-butanol–water–ammonia or *n*-butanol–water–acetic acid systems. Their positions were found under ultra-violet light, and the amounts were determined after cutting out the areas of paper and extracting with water.

By these procedures, it has been possible to demonstrate an exchange of purines and pyrimidines, linked as aglucones to the deoxyribosyl group, with free purines and pyrimidines which are added to the enzyme system. When deoxyribose phosphate[2] is tested in this system, however, with either purines or pyrimidines, no significant synthesis of deoxyribosides takes place. It is therefore concluded that the mechanism of exchange does not involve deoxyribose phosphate as the intermediate.

Thymine, uracil and 5-methyl cytosine (Dr. H. K. Mitchell kindly supplied this compound) have been found to be exchanged with purine deoxyribosides to give pyrimidine deoxyribosides. Chromatography has revealed that the pyrimidine deoxyribosides formed from thymine and uracil have R_P values identical with those of thymine deoxyriboside and uracil deoxyriboside respectively. The latter is of interest, since this is the first occasion upon which a biological role has been reported for this compound.

All the usual purines (except uric acid) and 4-amino-5-imidazole carboxamide (prepared from formylmalonamamidine hydrochloride, which was a gift from Dr. D. W. Woolley) react with pyrimidine deoxyribosides to give products which show the acid lability characteristic of purine deoxyribosides. Except for the fact that the product of the reaction between 4-amino-5-imidazole carboxamide and thymine deoxyriboside is not hypoxanthine deoxyriboside, nothing is known of its nature.

Certain other products have also been examined by chromatography on paper. Adenine is exchanged with uracil deoxyriboside to give adenine deoxyriboside. Xanthine is exchanged with uracil deoxyriboside to give a deoxyriboside having an R_P value of 0·06—a value less than that of any deoxyriboside at present known.

I wish to thank Dr. E. Hoff-Jørgensen and Dr. H. M. Kalckar for the use of their laboratories, and for their inspiration and help. Mrs. A. L. Ziesler gave technical assistance.

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Detection of Sugars on Paper Chromatograms

THE ammoniacal silver nitrate spray[1] used for the detection of sugars has several disadvantages; to those mentioned by Partridge[2] should be added the necessity for very careful control of the heating step, particularly important in laboratories lacking special apparatus. We have introduced modifications, based on a test given by Feigl[3] for reducing sugars, which eliminate the heating step, and in which the reagents are applied in organic solvents, thus removing the danger of migration of the sugar spots. The method has been in use for more than a year, and has proved easy to handle and extremely reliable.

In the modified procedure the dried, developed paper chromatogram strip is first passed rapidly through a reagent solution, prepared by diluting 0·1 ml. of saturated aqueous silver nitrate solution to 20 ml. with acetone, and adding water dropwise, with shaking, until the silver nitrate which separates on addition of acetone has redissolved. Spreading of the spots is limited on account of the sparing solubility of sugars in acetone (0·014 per cent at 23° C. for crystalline glucose[4]). The dry paper is sprayed with a 0·5 *N* solution of sodium hydroxide in aqueous ethanol, made by diluting saturated aqueous sodium hydroxide solution with ethanol. Brown silver oxide is immediately produced, the colour facilitating even spraying. Reducing-sugars form dense black spots of silver more or less rapidly at room temperature. When reduction is judged complete, excess silver oxide is dissolved by immersing the strip for a few minutes in 6 *N* ammonium hydroxide, after which the paper is washed for at least one hour in running

water, and dried in an oven. Black or dark brown spots on a white ground are obtained, except when phenol has been used as the developing agent, when the background is greyish. The spots can be rendered jet black by momentary exposure to hydrogen sulphide. A feature of the method is that substances other than reducing-sugars are detected. Thus glycerol[5] reacts at room temperature after a much longer period of contact with the reagent than is required for reducing-sugars. Under the same conditions, trehalose, a non-reducing disaccharide, reacts faintly; but the spot can be intensified by heating.

A similar technique for the detection of sugars has been employed, using triphenyltetrazolium chloride which, in alkaline solution, is reduced to the insoluble, intensely red, formazan compound. This property has been used in the analysis of reducing-sugars[6]. A 0·5 per cent solution of triphenyltetrazolium chloride in chloroform is applied as above, and after evaporating the solvent at room temperature, the strip is sprayed with an alcoholic solution of sodium hydroxide. After standing overnight, reducing-sugars develop intense red spots against a pink background, fructose and xylose reacting especially readily. The excess reagent is easily removed by irrigation with water. If rapid reaction is required, the long standing at room temperature may be replaced by five minutes heating at 100° C. in the oven in a moist atmosphere. Non-reducing disaccharides such as sucrose and trehalose do not react.

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Chromatography of Steroids on Alumina-impregnated Filter Paper

The method described below was developed with the view of detecting and estimating the small amounts of steroids present in the blood and tissues of mammals. It has proved very useful for studying the output of the adrenal gland, and is sufficiently sensitive to be used on small samples of human blood.

Detection of very small amounts of steroid on paper chromatograms presents difficulties, but two methods have proved very useful. In the first[1], the chromatogram is pressed down over Ilford Reflex No. 50 paper and exposed to a flash from an ultra-violet lamp. About 5 μgm. of an $\alpha\beta$-unsaturated steroid suffices to produce a light spot on the photograph, but the exposure must be as short as possible. A quicker and more sensitive method, which works with all steroids so far tested, is a modification of Brante's method for nitrogenous compounds[2]. The chromatogram is dipped for a few seconds into a saturated solution of iodine in petroleum (60–80°). If no spots are seen, the immersion is prolonged. Further increase in sensitivity can be obtained by heating the iodine solution to 40° C. on a water-bath. The sensitivity is markedly decreased by acid and various contaminants in the paper. The chief precautions needed are complete removal of traces of solvents, dryness and neutralization of acid by a short period in ammonia gas. The iodine solution must be kept fresh and fully saturated. In order to make the colours more permanent, the chromatogram can be sprayed with a concentrated starch solution when all background iodine has disappeared. This treatment often shows up previously invisible iodine spots.

This method seems surprisingly sensitive, and the reaction is peculiar in that it seems to depend very little on substituent groups in the steroid nucleus. However, some differences in colour are shown. Most steroids give a yellow colour; œstrone and œstradiol give a brownish colour; 11-dehydro-17-hydroxy corticosterone gives a yellow on alkaline, green on neutral and blue on acid papers (cf. Zaffaroni *et al.*[3]) and seems unique in this respect. Cortical extracts and adrenal venous blood extracts yield a very water-soluble fraction giving a red colour. This fraction has been partially split into spots giving orange, grey-green and crimson colours with iodine. Again, most steroids release their iodine completely to give the usual blue starch colour; but androsterone (and testosterone slightly) tend to give a pink colour with starch after iodine. This method will detect 1 γ gm. or less of steroid. A disadvantage is that a large number of non-steroid substances give this reaction[2].

The impregnated paper has been made by soaking Whatman paper No. 54 in a solution of 200 gm./l. ammonium alum at 60° C., hanging the soaked paper for 15 min. in a closed glass vessel, adding a liberal volume of 0·880 ammonia to the vessel and leaving overnight. The paper is then removed and washed in running water for six hours before drying. It seems essential to use a very dense precipitate, and to include the 15-min. hanging period in order to cover the cellulose completely. Otherwise large amounts of steroid remain on the origin of a chromatogram. Thus progesterone on dry untreated filter paper is not moved at all by a flow in benzene; but on alumina-paper it moves with an R_F of 0·85. Otherwise the method is entirely similar to that of Datta *et al.*[4].

In agreement with Datta *et al.*, the activity of the paper is found to vary very little with the temperature of drying. Two useful methods of varying the activity for steroid work have been found. For lowering the R_F values of phenolic steroids (and less for other steroids) soaking in $N/20$ ammonium hydroxide for four hours can be used. Again the activity can be raised and some separations improved by prolonging the period in running water when the tap water is hard.

Using only 6–9-in. strips, progesterone, œstrone and œstradiol are easily separated (R_F 0·85, 0·4, 0·1) by a benzene flow; œstrone, testosterone and androsterone are best separated by tetralin; the acetates of deoxycorticosterone, 11-dehydrocorticosterone, corticosterone, and 17-hydroxycorticosterone are separated by a single flow in benzene (R_F 0·76, 0·4, 0·24, 0·1). Cortical steroids are rapidly destroyed on alumina[6] and 'tail' badly: 21-acetylation prevents these losses, and masks their common 21-hydroxyl group so as to render their differences more apparent on a chromatogram.

Attempts to use other precipitates in paper have given poor results, since most other adsorbents have

to be precipitated with aqueous reagents and seem to leave much cellulose uncovered. Further, it seems that so-called 'weak' adsorbents become much more active when precipitated in paper.

This work was done while holding a studentship of the Medical Research Council. I am indebted to Prof. T. Reichstein for samples of pure cortical steroids, to Dr. T. Mann for samples of progesterone and testosterone, and to Prof. C. W. Shoppee, Dr. C. S. Hanes and Dr. P. R. Lewis for much helpful advice.

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Boveri and the Early Days of Genetics

Prof. R. C. Punnett's informative and charming account of "Early Days of Genetics"[1] ends with a statement which for the sake of historical justice requires comment. In answer to the question why the discoverers of linkage "managed to miss the tie-up of linkage phenomena with the chromosomes", Punnett says: "The answer is Boveri. We were deeply impressed by his paper 'On the individuality of the chromosomes' and felt that any tampering with them by way of breakage and recombination was forbidden."

Boveri himself, however, not only interpreted the theory of the individuality of chromosomes liberally enough to permit exchanges of chromosome parts but also explicitly predicted the discovery of genetic linkage and crossing over, and provided the now accepted cytological interpretation. In his famous "Ergebnisse über die Konstitution der Chromatischen Substanz des Zellkerns" (Jena, 1904), Boveri summarizes in chapter 1 the theory of the individuality of chromosomes, quoting and enlarging upon his statement of 1887: "I regard the socalled chromatic segments or elements as individuals, I might say as the most elementary organisms which lead their independent existence in the cell." In chapter 5, which deals with meiosis, Boveri discusses the pairing of chromosomes as follows: ". . . that . . . possibly a process is involved which corresponds to the conjugation of unicellular organisms so that if we say that the copulating chromosomes separate again in the the second (or first) maturation division, this should not be regarded as of different meaning than if we say the same of two ex-conjugated Paramecia. They are not any more the same which had conjugated, for they have mutually exchanged certain parts."

The prophetic statement on the cytogenetics of linkage and crossing-over occurs on page 118 in the final chapter, immediately after Boveri's exposition of the chromosomal basis of the Mendelian laws. It is reproduced here in the original German and in translation. The sentences in italics are in roman type in the original. They have been underlined by the late Karl Belar in his copy of the book now in my possession. More than twenty years ago, Belar directed my attention to Boveri's prediction:

If "zwei Merkmale bei fortgesetzter Zucht immer gemeinsam auftreten oder gemeinsam verschwinden, mit grösster Wahrscheinlichkeit den Schluss zu ziehen erlauben, dass die Anlagen für diese beiden Merkmale in dem gleichen Chromosoma lokalisiert sind. *Und weiter: wenn sich eine Bastardierung auf zahlreiche Merkmale erstreckt und sich bei fortgesetzter Zucht ergibt, dass die Zahl der Kombinationen, in welchen die einzelnen Merkmale verbunden sein können, grösser ist als es den Kombinationsmöglichkeiten der vorhandenen Chromosomen entspricht, so wäre daraus zu folgern, dass die in einem Chromosoma lokalisierten Merkmale sich bei der Reduktionsteilung unabhängig voneinander in die eine oder die andere Tochterzelle begeben können, was auf einen Umtausch von Teilen zwischen den homologen Chromosomen hinweisen würde.*" (If "in successive breeding two traits should always appear together or disappear together, then it would be permitted to draw the conclusion, with the highest probability, that the *anlagen* for these two traits are localized in the same chromosome. *And furthermore: if a hybridization experiment included numerous traits and if it should be found in successive breeding that the number of combinations in which the separate traits can occur, is greater than it would correspond to the possibilities of recombination of the chromosomes present then it would have to be concluded that the traits localized in a chromosome can go independently of each other into one or the other daughter cell which would point to an exchange of parts between the homologous chromosomes.*")

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May 20.

[1] Punnett, R. C., *Heredity*, **4**, 1 (1950).

Chromosome Numbers of *Cerastium* Species

The chromosomes of four species of *Cerastium*, namely, *C. vulgatum*, *C. alpinum* (including *C. alpinum lanatum*), *C. arvense* and *C. perfoliatum*, have been counted from root-tips of young seedlings. I give here a list of chromosome counts made by previous workers, none of which is of British material, together with my own counts.

Species	2*n*	Author	Date
C. vulgatum	144	Rohweder[1]	1939
C. ,,	126	Hagerup[2]	1944
C. alpinum	72	Böcher[3]	1944
C. ,,	72	Löve and Löve[4]	1944
C. ,,	108	Sörensen and Westergaard	from Löve and Löve[4]
C. arvense	72	Rohweder[1]	1939
		Original source of material	
C. vulgatum	136	The Weald, Sussex, England	
C. alpinum	72	Auchlean, Inverness-shire, Scotland	
C. alpinum lanatum	72, 108	Not known (from Th. Ingwersen)	
C. arvense	38	Oetztal, Tirol, Austria	
C. perfoliatum	38	Not known (from Chelsea Physic Garden)	

The count $2n = 136$ for *C. vulgatum* differs from counts made with Continental material[1,2]. This species is very variable, and work is in progress on material collected from other parts of Britain.

Two different counts for *C. alpinum*, $2n = 72$ and $2n = 108$, have been confirmed. The higher number, $2n = 108$, was found only in one seedling of *C. alpinum lanatum*. Sörensen and Westergaard's count of $2n = 108$ was made from material collected in Greenland. The occasional presence of $2n = 108$ plants among $2n = 72$ material strongly suggests that the $2n = 108$ plants have arisen as a result of chromosome doubling in the $2n = 72$ plants.

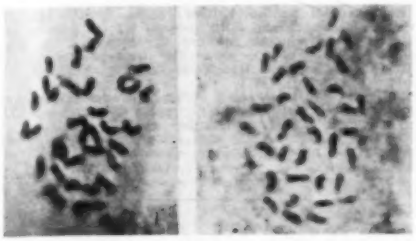

Fig. 1. Somatic metaphase plate of *C. arvense* showing 38 chromosomes. × *c.* 2,000

Fig. 2. Somatic metaphase plate of *C. perfoliatum* showing 38 chromosomes. × *c.* 2,000

The two counts of $2n = 38$ for *C. arvense* and *C. perfoliatum* (see figs.) are both new. Rohweder counted $2n = 72$ for *C. arvense*. The number $2n = 38$ has also been counted[1] for *C. tomentosum* and *C. chlorœfolium*. It is therefore concluded probable that 19($2n = 38$) is the basic number for one section of the genus. This would be an additional basic number for *Cerastium*; previously 9 has been stated to be the basic number[2]. The species *C. arvense*, a remarkably variable one, appears to include both basic numbers. Further work on British material of *C. arvense* is in progress.

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May 5.

[1] Rohweder, H., *Beih. Bot. Centralblatt*, **59** B (1939).
[2] Hagerup, O., *Hereditas*, **30** (1944).
[3] Böcher, T. W., *Svensk Botan. Tid.*, **32** (1938).
[4] Löve, A., and Löve, D., *Arkiv för Bot.*, **31** (1944).
[5] Löve, A., and Löve, D., Dept. Agric. Report, Reykjavik, Series B, No. 2 (1948).

Sagitta setosa J. Müller in the Clyde

The Chætognatha of Scottish waters have been discussed by Fraser[1–3]. *Sagitta elegans* Verrill is the dominant form, and appears to be found particularly in those areas where Atlantic water mixes with coastal water. *S. setosa*, except for a few specimens at the northern entrance of the Irish Sea (in July), was absent from the north and west coasts of Scotland. Russell[4], in examining collections of Farran, found *S. setosa* late in the year at the entrance to the North Channel of the Irish Sea. Both Fraser and Russell consider the *S. setosa* of the Irish coast to have filtered out from the Irish Sea. Russell considers they may have drifted up through St. George's Channel. Pierce[5,6] has found *S. setosa* together with *S. elegans* along the English west coast from Morecambe Bay to Anglesey, and considers they are indigenous to that area.

In the Clyde area the form recorded is *S. elegans*, and, although no regular and systematic observations have been made on this group hitherto, the consensus of opinion is that *S. setosa* has never been noted. This is perhaps surprising in view of the comparatively low salinities[7] often observed in this area (mean surface salinity, Keppel Pier, 1949 = 31·88‰), since Furnestin[8] has found *S. setosa* in the Gulf of Gascogne where the Gironde estuary lowers the salinity. The occurrence of considerable numbers of this species well inside the Clyde area is therefore of interest. *S. setosa* was first observed in November 1949 in Loch Fyne, a few specimens being taken in both the upper and lower parts of the loch at a depth of 8–10 metres. In December a large catch of *S. setosa* was obtained off the south of Bute.

The latter catches were taken in eight horizontal hauls at 25 metres with small nets (46 cm. diameter), the mean catch per tow of 1 mile being thirty animals. A large proportion (74 per cent) of the animals appeared to be in a moribund condition, and all were immature. In both state of development and size (mean length, 11·6 mm.; range, 9·2–14·0 mm.; standard error of mean, ± 0·08 mm.) the catch was homogeneous. Dr. Fraser points out that these *S. setosa* are rather more heavily muscled than those of the North Sea, and resemble a few specimens he recently found in the Minch area. Pierce found that in the Mersey Channel the *S. setosa* reached their maximum numbers in October, and in November the population consisted largely of immature (stage I) individuals (modal length ≏ 12 mm., range 9·0–16·0 mm., values read from the graph).

Proudman[9] has indicated a mean current from south to north through the Irish Sea; but the general absence of *S. setosa* from the Clyde area suggests that little of the Irish Sea water finds its way into this area; this is substantiated by the difference in plankton between these areas (Herdman[10]). However, the present observations, particularly the agreement of the measurements with those given by Pierce, together with the records of Russell and Fraser, indicate that in the autumn there is some transport of water from the Irish Sea into the Clyde. It is possible, however, that Irish Sea water is only detected in the Clyde area during the autumn by *S. setosa*, since this species is then at a maximum in the Irish Sea.

Thanks are due to Dr. J. H. Fraser, both for confirming the identity of the specimens and for his critical comments.

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May 17.

[1] Fraser, J. H., *J. Cons. Int. Explor. Mer.*, **12**, No. 3, 311 (1937).
[2] Fraser, J. H., *ibid.*, **14**, No. 1, 25 (1939).
[3] Fraser, J. H., *J. Mar. Biol. Assoc.*, **28**, No. 2, 489 (1949).
[4] Russell, F. S., *ibid.*, **20**, 309 (1935).
[5] Pierce, E. L., *ibid.*, **25**, 113 (1941).
[6] Pierce, E. L., and Orton, J. H., *Nature*, **144**, 784 (1939).
[7] Marshall, S. M., and Orr, A. P., *J. Mar. Biol. Assoc.*, **14**, No. 4, 837 (1927).
[8] Furnestin, J., *Revue des Trav. de l'Office des Pêches Maritimes*, **11**, fasc. 3, 425 (1938).
[9] Proudman, J., *Phil. Trans. Roy. Soc.*, A, **239**, No. 812, 579 (1946).
[10] Herdman, W. A., *J. Linn. Soc. (Zool.)*, **32**, No. 208, 23 (1911).

FORTHCOMING EVENT

*(Meeting marked with an asterisk * is open to the public)*

Wednesday, September 13

INSTITUTE OF PETROLEUM (at 26 Portland Place, London, W.1), at 5.30 p.m.—Mr. L. W. Cabot, Mr. J. W. Edminster and Mr. C. A. Stokes: "Manufacture of Furnace Carbon Black from Liquid Hydrocarbons at Ellesmere Port".*

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT AGRICULTURAL ECONOMISTS (with a degree in agriculture or economics)—The Registrar, The University, Manchester 13 (September 15).

ASSISTANT LECTURER OR LECTURER IN GENERAL BACTERIOLOGY in the Department of Botany—The Registrar, University College, Cathays Park, Cardiff (September 16).

CHEMISTS in the Executive's Laboratory Service: (1) (Ref. F/EV. 139a) with experience in the investigation of problems other than metallurgical such as arise in the use, maintenance and repair of rolling stock, vehicles, permanent way and buildings; (2) (Ref. F/EV. 139b) with experience of paints and paint testing, together with the investigation of problems arising in connexion with the use of paints and other protective treatments—The Staff Officer, London Transport Executive, 55 Broadway, London, S.W.1, quoting the appropriate Ref. No. (September 16).

LECTURER IN CHEMISTRY, and a LECTURER IN MATHEMATICS—The Registrar, Birmingham Central Technical College, Suffolk Street, Birmingham 1 (September 16).

LECTURER IN FUEL TECHNOLOGY—The Registrar, The University, Leeds 2 (September 16).

SENIOR LECTURER IN CHEMISTRY—The Principal, Chelsea Polytechnic, Manresa Road, London, S.W.3 (September 16).

CHEMISTS (with a University degree with first- or second-class honours in chemistry) in the Research Laboratories at Leatherhead—The Secretary's Office (Establishments), Applications Section, British Electricity Authority, British Electricity House, Great Portland Street, London, W.1, quoting Ref. AE/83 (September 18).

CARTOGRAPHER (graduate in geography)—The Secretary, The University, Aberdeen (September 20).

NUTRITIONIST in the Department of Health—The Secretary to the High Commissioner for Southern Rhodesia, Rhodesia House, 429 Strand, London, W.C.2 (September 20).

LECTURER IN THE DEPARTMENT OF PHYSICS (with a good degree and, preferably, teaching experience), and a LECTURER (with a good degree in chemistry and, preferably, teaching and/or industrial experience) IN THE DEPARTMENT OF CHEMISTRY, Leeds College of Technology—The Chief Education Officer, Education Department, Leeds 1 (September 23).

PHYSIOLOGISTS (male) with wide interests in human applied physiology, as Principal Scientific Officer or Senior Scientific Officer at a Ministry of Supply research unit in Hampshire—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting G.235/50 (September 23).

CHEMICAL ENGINEER with research experience to take charge of the Carbonization Section in the Board's Central Research Establishment at Stoke Orchard, Cheltenham—The National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, marking envelope TT/246 (September 25).

LECTURER IN FUEL TECHNOLOGY—The Registrar, College of Technology, Manchester 1 (September 25).

PRINCIPAL SCIENTIFIC OFFICER to take charge of the Technical Information Services of a Ministry of Supply Research Establishment near London—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting A.244/50A (September 29).

SCIENTIFIC LIBRARIAN (Experimental Officer grade) in a Ministry of Supply Research Establishment near London—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting A.245/50A (September 29).

PROFESSOR OF AGRICULTURAL BOTANY (with special reference to Cytogenetics)—The Registrar, University College of Wales, Aberystwyth (September 30).

RESEARCH POST IN EXPERIMENTAL PATHOLOGY—The House Governor and Secretary, Royal Cancer Hospital, Fulham Road, London, S.W.3 (September 30).

SENIOR LECTURER IN CIVIL ENGINEERING at the University of Cape Town—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (September 30).

SENIOR RESEARCH OFFICER OR RESEARCH OFFICER IN THE SECTION OF METEOROLOGICAL PHYSICS, C.S.I.R.O., Highett, Victoria, to assist in research into the general circulation of the atmosphere and engage in fundamental research associated with synoptic meteorology of the region—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting No. 2984 (September 30).

SENIOR LECTURER OR LECTURER IN PSYCHOLOGY at the University of Sydney—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (Sydney, October 9).

PROFESSOR OF MICROBIOLOGY—The Registrar, The University, Reading (October 10).

SCIENTIFIC ASSISTANT (with a degree in botany or related subject) for the collation, abstracting and reviewing of biological literature—The Director, Commonwealth Bureau of Plant Breeding and Genetics, School of Agriculture, Cambridge (October 21).

CHAIR OF PURE MATHEMATICS—The Secretary, Queen's University, Belfast (November 15).

ASSISTANT CIVIL ENGINEER in the Office of the Engineer-in-Chief, at the War Office—The War Office, (C.5(A)), Room 503, Hotel Victoria, Northumberland Avenue, London, W.C.2.

ASSISTANT LECTURER IN PHYSICS—The Registrar, The University, Nottingham.

DEPARTMENTAL ASSISTANT IN POULTRY HUSBANDRY at the School of Agriculture, Sutton Bonington—The Registrar, The University, Nottingham.

LECTURER (Grade IIa) IN CHEMISTRY—The Clerk and Treasurer, Dundee Technical College, 40 Bell Street, Dundee.

LECTURER IN MECHANICAL ENGINEERING (particularly Thermodynamics)—The Secretary, Royal Technical College, Glasgow.

LECTURER IN RUBBER TECHNOLOGY—The Clerk, National College of Rubber Technology, Northern Polytechnic, Holloway, London, N.7.

RESEARCH OFFICER (Senior Scientific Officer) at the Ebini Livestock Experimental Station, British Guiana, for the planning and supervision of research and other projects for the purpose of ascertaining the most economic methods of developing the mineral-deficient savannahs of the area—The Under-Secretary of State, Colonial Office, Research Department, Sanctuary Buildings, Great Smith Street, London, S.W.1.

STEROID CHEMIST to conduct research on steroid metabolism in rheumatic diseases, with particular reference to excretion—The Chief Administrative Officer, Royal Hospital, Sheffield 1.

TECHNICIAN (Grade III) IN THE DEPARTMENT OF GEOGRAPHY—The Secretary, University College, Gower Street, London, W.C.1, quoting 'Geography/3'.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Science Museum. Aeronautics: Lighter-than-Air Craft: a Brief Outline of the History and Development of the Balloon and the Airship, with reference to the National Aeronautical Collection, and a Catalogue of the Exhibits. By M. J. B. Davy. Pp. 112+32 plates. (London: H.M. Stationery Office, 1950.) 5*s*. net. [107

Fitzwilliam Museum, Cambridge. Annual Report for the Year ending 31 December 1949. Pp. 10+4 plates. Friends of the Fitzwilliam Museum. Forty-first Annual Report for the Year 1949. Pp. 8. (Cambridge: Fitzwilliam Museum, 1950.) [107

Forestry Commission. Report on Forest Research for the Year ending March 1949. Pp. 80. (London: H.M. Stationery Office, 1950.) 1*s*. 9*d*. net. [107

National Forest Park Guides. Glen Trool. (Issued by the Forestry Commission.) Pp. iv+78. (London: H.M. Stationery Office, 1950.) 3*s*. net. [107

Forestry Commission. Britain's Forests—Kielder. Pp. 16. (London: H.M. Stationery Office, 1950.) 6*d*. net. [107

London School of Hygiene and Tropical Medicine. Report on the Work of the School for the Year 1948–1949. Pp. 94. (London: London School of Hygiene and Tropical Medicine, 1950.) [137

British Empire Cancer Campaign. Twenty-seventh Annual Report covering the Year 1949. Edited by Sir Heneage Ogilvie. Pp. 363. (London: British Empire Cancer Campaign, 1950.) [137

Other Countries

United Nations. Catalogue of Economic and Social Projects, 1950. Pp. xx+515. (Lake Success, N.Y.: United Nations; London: H.M. Stationery Office, 1950.) 3.75 dollars; 27*s*. 6*d*. [137

Proceedings of the American Philosophical Society. Vol. 94, No. 3: Studies of Historical Documents in the Library of the American Philosophical Society. Pp. 183–310. (Philadelphia: American Philosophical Society, 1950.) 1 dollar. [137

United States Department of Commerce: Weather Bureau. Research Paper No. 29: An Objective Method of Forecasting Five-Day Precipitation for the Tennessee Valley. By William H. Klein. Pp. iv+60. 30 cents. Research Paper No. 31: Second Partial Report on the Artificial Production of Precipitation; Cumuliform Clouds, Ohio, 1948. By Richard D. Coons, Earl L. Jones and Ross Gunn. Pp. iii+58. 30 cents. Research Paper No. 32: Further Studies in Hawaiian Precipitation. By Samuel B. Solot. Pp. viii+37. 30 cents. Research Paper No. 33: Artificial Production of Precipitation. Third Partial Report; Orographic Stratiform Clouds, California, 1949; Fourth Partial Report: Cumuliform Clouds, Gulf States, 1949. By Richard D. Coons, Earl L. Jones and Ross Gunn. Pp. iii+46. n.p. (Washington, D.C.: Government Printing Office, 1949–1950.) [137

United States Department of Commerce: Weather Bureau. Technical Paper No. 7: A Report on Thunderstorm Conditions affecting Flight Operations. Pp. iv+32. 15 cents. Technical Paper No. 9: Temperatures at Selected Stations in the United States, Alaska, Hawaii and Puerto Rico. Pp. iii+20. 15 cents. Technical Paper No. 10: Mean Precipitable Water in the United States. Pp. iv–48. 30 cents. Technical Paper No. 11: Weekly Mean Values of Daily Total Solar and Sky Radiation. Prepared by I. F. Hand. Pp. ii+17. 15 cents. (Washington, D.C.: Government Printing Office, 1948–1949.) [137

Catalogues

Salts of Tungsten, Molybdenum and Vanadium. Pp. 4. (Rainham: Murex, Ltd., 1950.)

L.D.C. Service To-day. (ML.68.) Pp. 8. (London: Lancashire Dynamo and Crypto, Ltd., 1950.)

Murfume Smokes. Pp. 16. (Wheathampstead: The Murphy Chemical Co., Ltd., 1950.)

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